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OPENING OF THE PARIS EXPOSITION.

By Our Regular Correspondent.

THE Paris Exposition was formally inaugurated on April 14, and the grounds were thrown open to the public on the day following. Two or three days before the opening the scaffoldings still remained upon

the façades of many of the buildings, notably upon the sculptured groups of the Grand and Petit Palaces and upon the Electric Fountain, and the grounds were in a somewhat chaotic condition. The Champ de Mars was filled with freight cars containing the exhibits and parts of the large dynamos, and no one would have thought that the inauguration would take place under

anything like favorable auspices. However, at the last moment, an army of workmen cleared away the scaffoldings from all the façades, grass and trees were placed between the Grand and Petit Palaces, the sidewalks were laid, and on the Alexandre III. Bridge the painting and gilding was finished and the last parts of the bronze candelabra mounted. The immense Salle



THE INAUGURATION OF THE PARIS EXPOSITION—PRESIDENT LOUBET DECLARING THE EXPOSITION OPEN.

des Fêtes in the Champ de Mars, which a few days before had been filled with beams and scaffolding, was entirely cleared, and the seats and loges arranged and draped for the inauguration ceremony. This great hall has been erected in the middle of the Galerie des Machines, an immense iron and glass structure remaining from the exposition of 1889. The Salle des Fêtes is of circular form having an area of 6,300 square meters and will contain 35,000 persons. Its ceiling is hemispherical, and is supported upon a series of columns and circular arches; it is arranged in amphitheater form, the great circular floor being surrounded by rows of seats and tribunes. The upper part of the ceiling is composed of stained glass laid out in a many-colored pattern, giving a very rich effect. The hall is decorated with large panels, by Cornon, François Flameng, and



ARRIVAL OF THE PRESIDENTIAL BARGE AT THE PLACE DE LA CONCORDE.

other eminent artists, and with sculptured groups, carving and gilding. At the time of the inauguration it presented an animated scene, being filled with an immense throng made up of senators, deputies, foreign legations and invited guests. The Presidential party entered shortly after two o'clock, amid the sounds of the Marseillaise rendered by an immense orchestra and chorus. M. Millerand, the minister of commerce, delivered the opening discourse, after which President Loubet gave the inauguration address, in which he announced the high purpose of the exposition in the advance of civilization, and its aid in mutual instruction. Higher than this are the moral forces which are at work to produce the material results which now appear, due to the cooperation of the various intelligences of all nations. He salutes the different governments represented and closes with the hope that the new century will see a closer fraternity between them and that an important step will have been taken in the evolution of labor toward happiness and of mankind toward the idea of humanity. He then declared the Exposition of 1900 to be formally opened. After this speech, which was warmly applauded, M. Loubet proceeded to the reception room, where he received a number of

representatives of different countries. The party then passed into the Electrical Palace and reviewed a number of the exhibits which were already in place. At the United States pavilion the salute was given with the American flag.

A tour of the grounds was made, commencing with the Electric Fountain, which had been entirely cleared of scaffolding, although not completely finished. It presented an imposing appearance with its richly designed arch and central niche, with the numerous sculptured groups which surrounded it. After passing along the Champ de Mars between the long row of façades in white staff, the party embarked in three boats at the Pont d'Iena and proceeded along the river between the line of palaces and buildings on either side; they were saluted by the crowds of visitors gathered at every available point. Upon passing the long series of National pavilions, each of these gave the salute by the lowering of flags, playing of National airs, etc. The United States saluted the party by lowering the two large flags which are placed one on each end of the terrace, while between these two French flags were held out stationary. The party disembarked at the end of the Alexandre III. Bridge, on the left bank, crossing the bridge and passing between the Grand and Petit Palaces. The white façades with their rich ornamentation and sculptured groups, with the grass and trees under a brilliant sky, gave an imposing effect. The Presidential party were escorted by a regiment of infantry, and the space was filled with the fortunate spectators who secured an entry to the grounds. This terminated the inauguration ceremony, and the President was escorted back to the Elysee by a regiment of cuirassiers.

A TOUR OF THE EXPOSITION.

THE changes which were made upon the grounds and within the buildings of the Paris Exposition in the twenty-four hours that preceded the opening were most remarkable. Roads that were almost impassable to wheeled vehicles were metamorphosed into well-leveled and graveled paths. An indescribable confusion of packing cases, and scaffolding and debris gave way to order. In addition to the army of workmen that were engaged upon this labor, whole regiments of soldiers were sent in the grounds to assist, so that it is little wonder that chaos yielded to the power of concentrated organization. This gave a factitious air of completeness, but the day after the opening many of the scaffoldings were again placed in position and the work was continued. It is a tradition that exhibitions are never completed at the appointed time; for the most part this is the fault of the exhibitors who are always slow in forwarding their exhibits and installing them. As the time for the openings of expositions approaches, there is a dearth of railway cars to transport the goods. Many weeks will have to elapse after the opening before the exhibition can be seen in its complete form.

By a reference to the various maps and plans the general scheme of distribution of the buildings will be noted. The promenade of the grounds and buildings naturally begins at the Place de la Concorde, where access to the grounds is gained by the monumental en-

trance which is shown in one of our engravings. It is a curious and fantastic structure, and is very interesting from an engineering point of view; the criticism of its structure and decoration is, in the main, invariable, even Parisian opinion is loud in ridicule of its form and glaring color. The work appears even more unsatisfactory since the statue which represents the city of Paris welcoming her guests has been put in place. The figure is that of a woman in a very modern ball costume, and the result is disagreeable. The statue is of gigantic size, and it dwarfs the entrance. The gateway, with its dome and statue, conveys neither an idea of usefulness nor stability. The circular arrangement is admirable; the visitors enter through a great archway and then turn right and left to the turnstiles, which are arranged like the sticks of a fan. A door-



THE PRESIDENTIAL BARGE AT THE PONT D'IEA.

way in the center of the structure is to be used only by sovereigns and other great personages; it opens directly upon a row of trees, which the municipality would not allow to be disturbed. Along the banks of the Seine are horticultural and arboricultural exhibits. Following the route on the side of the river, we reach the broad avenue from which the view of the Alexandre III. Bridge and the Esplanade des Invalides is obtained. From here an excellent idea can be obtained of the general effect of the new bridge, which appears to be somewhat overloaded with ornament. Before crossing the Seine let us glance at the two fine art palaces, which are to be permanent. The effect of the smaller place is charming. Marbles of different colors have been employed in profusion with very harmonious result, while the appearance of the interior court is excellent. This building contains the retrospective collections of French art. The large palace of fine arts is not so pleasing from an architectural point of view, a curved and iron covered roof producing a bad effect when taken in connection with the classic stone colonnade. The rounded ends are also out of harmony with the rest of the building. The structure is of imposing size and the collections are, of course, among the most

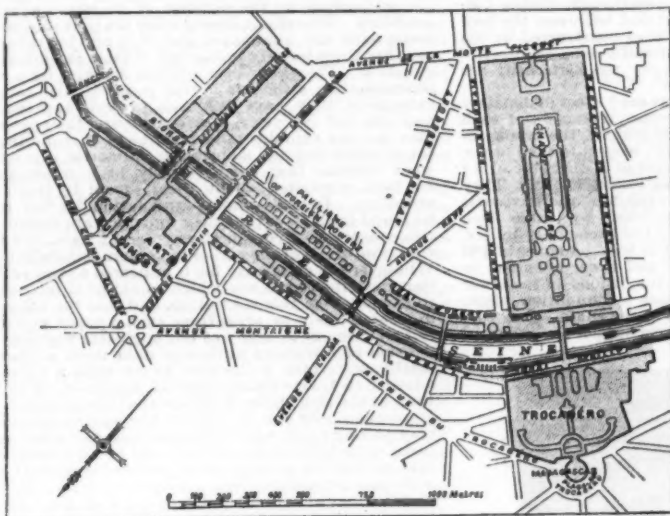


THE CONDITION OF THE ELECTRICITY BUILDING AND ITS FOUNTAIN TWELVE HOURS BEFORE THE INAUGURATION.

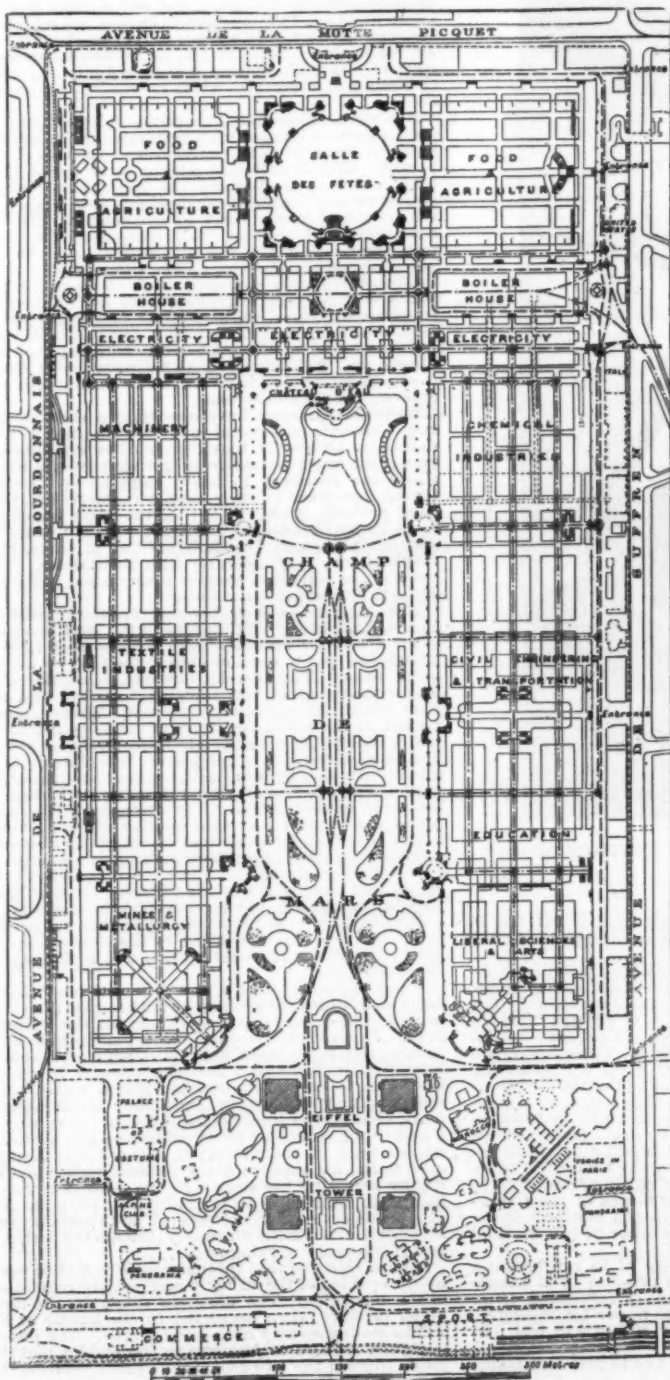
interesting of exhibits. Some weeks must elapse before the building is in a thoroughly satisfactory condition. Next, passing down the long avenue, the number of minor buildings and concessions will be seen, the principal one is "Le Vieux Paris," which we illustrated in the SCIENTIFIC AMERICAN SUPPLEMENT for Feb. 17, 1900. It is a reproduction of a mediæval city, and to reach this part of the exposition it is necessary to

cross a public avenue which intersects the exposition grounds. This is done by means of an overhead bridge. These bridges were far behind at the time of the opening of the grounds. Retracing our steps, we cross over to the Seine by the Alexandre III. Bridge, and one of the great divisions of the exposition is reached. The façades of the solid ranks of the buildings are more highly decorated than those facing the Seine, and their

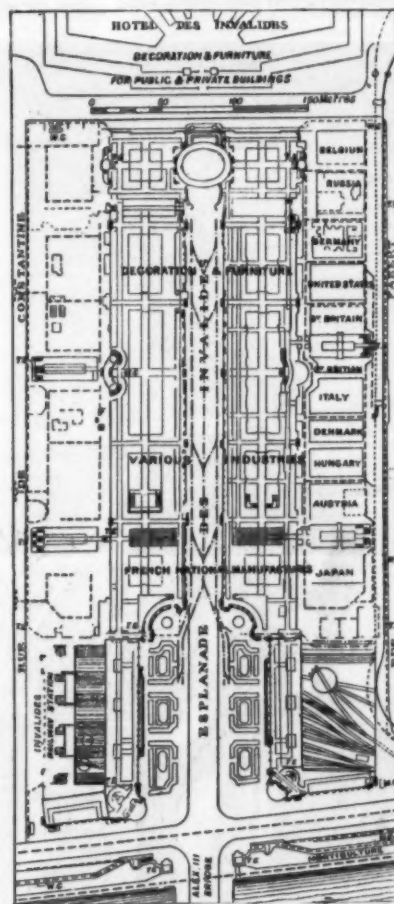
polychromatic decoration is not, in all cases, in good taste, but the collection of buildings is a most imposing and impressive one. Passing from the Esplanade des Invalides, we come to the "Street of Nations," a title borrowed from the exhibition of 1878, when a somewhat similar range of international pavilions formed a striking feature on the Champ de Mars. Here will be found the moving sidewalk, which is now in operation. Many of the buildings are costly and impressive; the International building is particularly fine, and we have illustrated the pavilion of the United States in the SCIENTIFIC AMERICAN SUPPLEMENT for Sept. 30, 1899. Many of the smaller buildings are extremely interesting as examples of native architecture, particularly the little pavilion of Bosnia. All the pavilions are constructed on a half basement over the low level railway of the Esplanade des Invalides. This arrangement raises the buildings six or seven feet above the ground level. Some of the grounds around these buildings are decorated with native shrubs and flowers. Thus, in the gardens of the building erected by the principality of Monaco, will be found the aloe and cactus. The Army and Navy pavilion has passed through many mishaps, the chief of which was the collapse of a considerable part of its framework. Behind this building are several annexed for the exhibition of war material. One of the most attractive of these is that of Vickers, Sons and Maxim. The pavilion is built



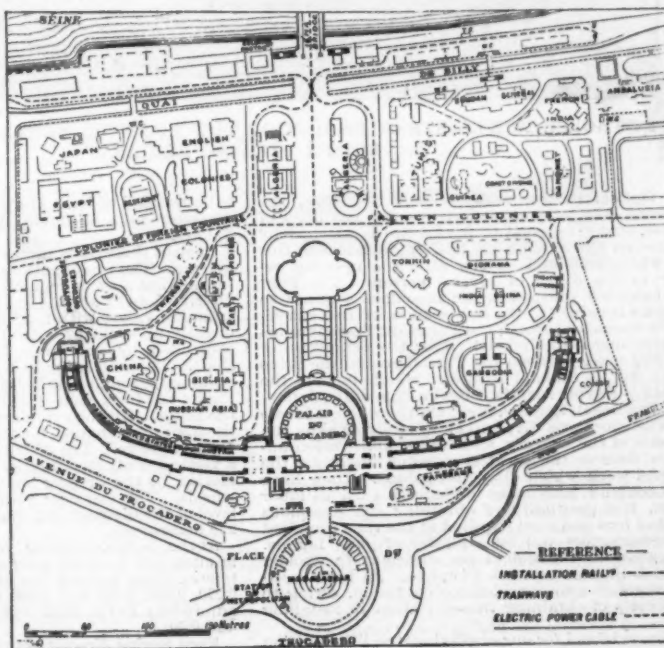
GENERAL ARRANGEMENT OF THE EXPOSITION.



THE CHAMP DE MARS SECTION.



THE ESPLANADE DES INVALIDES.



THE TROCADERO SECTION.

to imitate the section of an ironclad, and the pavilion erected by Messrs. Schneider & Company, for their own exhibits, is also notable. Near by is the pavilion for the Merchant Marine and buildings devoted to forestry, fisheries, etc.

The Champ des Mars is the most extensive portion of the exhibition, it somewhat resembles the letter U in shape. Passing under the Eiffel Tower, on the left are buildings devoted to mines and metallurgy, textiles, mechanics and electricity. The various countries have surrounded the space placed at their disposal in the different buildings with enclosures more or less elaborate, as was done in our own exposition of 1893. The machinery section is most important, and the installations are very backward. The Salle des Fêtes, where the opening ceremonies were held, is directly back of the electrical section, and the elaborate fountain occupies the greater part of the façade, forming a Château d'Eau. The old Machinery Hall was saved from the exhibition of 1893. On each side of the Salle des Fêtes the great area of Machinery Hall is devoted to agriculture and food products. On one side are the exhibits of France, and on the other those of foreign countries. The building devoted to the chemical industry is next reached, and the visitor then proceeds to the civil engineering and transportation building, finally making his exit from the buildings devoted to education, letters, sciences and arts. The railroad station abuts the group of buildings on the Champ de Mars. Around the Eiffel Tower are grouped various concessions, such

STEAM ENGINES OF 3,000 HORSE POWER.

DURING the course of the year 1899 some steam engines of 3,000 horse power were set up in the electric central station that the Berliner Maschinenbaugesellschaft has established on Luisen Strasse. These engines, which are three in number, are remarkable by reason of their high power and by the various arrangements that they present. They are vertical, with triple expansion and four cylinders, and each drives two dynamos mounted to the right and left upon the prolongation of the shaft. They were constructed by the Sulzer Brothers, of Winterthur, and a complete description of them has been given in the *Zeitschrift des Vereines Deutscher Ingenieure*.

The two low-pressure cylinders are 5.8 feet in diameter and are placed at the lower part, alongside of each other. Each of them actuates a shaft, the cranks of which are set on angle of 90° with respect to each other. The medium pressure cylinder has a diameter of 4.1 feet, and the high pressure one a diameter of 3.73. They are fixed upon the two other cylinders and have rods in common. They are supported by three iron columns fixed to the walls of the low pressure cylinders. The stroke of all the pistons is 4.36 feet. A space of 3.93 feet is left between the upper and lower cylinders in order to permit of the exit of the pistons of the lower cylinders. The frame comprises a foundation plate, which carries the pillow blocks of the shaft. Two cast iron uprights placed in the rear support a group of

kilowatts at a difference of potential of from 250 to 280 volts.

PORTABLE PNEUMATIC TOOLS.

By MR. EWART C. AMOS.

THE engineering industry at the present time is enjoying a period of activity quite unprecedented in its history, and, as a consequence, is calling for an immense increase in the number of its labor-reducing machines. Prominent among these are portable pneumatic tools and appliances, and it is not too much to say that there is every indication of their extended application. They have been used in America for a considerable time, although in this country, with certain exceptions, they have not been so well appreciated until the last few years, and considering their importance and the valuable assistance they are rendering to the shipbuilding and many other industries, it is somewhat singular that comparatively little information has been circulated about them except by trade descriptions. Doubtless some explanation for this is to be found in the fact that their practical application in this country is of comparatively recent date, and further, that some of the earlier tools were unsatisfactory. Whatever the cause may be, it appeared to the author that the subject was one which would be of interest to the members of this institution, and that the valuable discussion likely to arise from such a paper would be of great benefit to many of our engineers who may be desirous of obtaining authentic data upon a class of machinery which is likely to prove such a valuable adjunct to their existing types of machines. The author, at the same time, is aware that the subject is by no means a new one to some of the leading and more enterprising firms, who have experimented with pneumatic tools for some years past; and he also recognizes that certain kinds of portable pneumatic riveters and other appliances have been in constant use for a considerable time but he ventures to hope that the various tools described and illustrated in this paper may be of interest, as showing what has been achieved up to the present date. The various tools which can be driven by compressed air are many, and are rapidly increasing in number; but in order to confine the subject to the limits permitted in a paper of this description, the author proposes only to refer to portable hammers, riveters, and drills, making also a very brief reference to hoists and other appliances driven by compressed air.

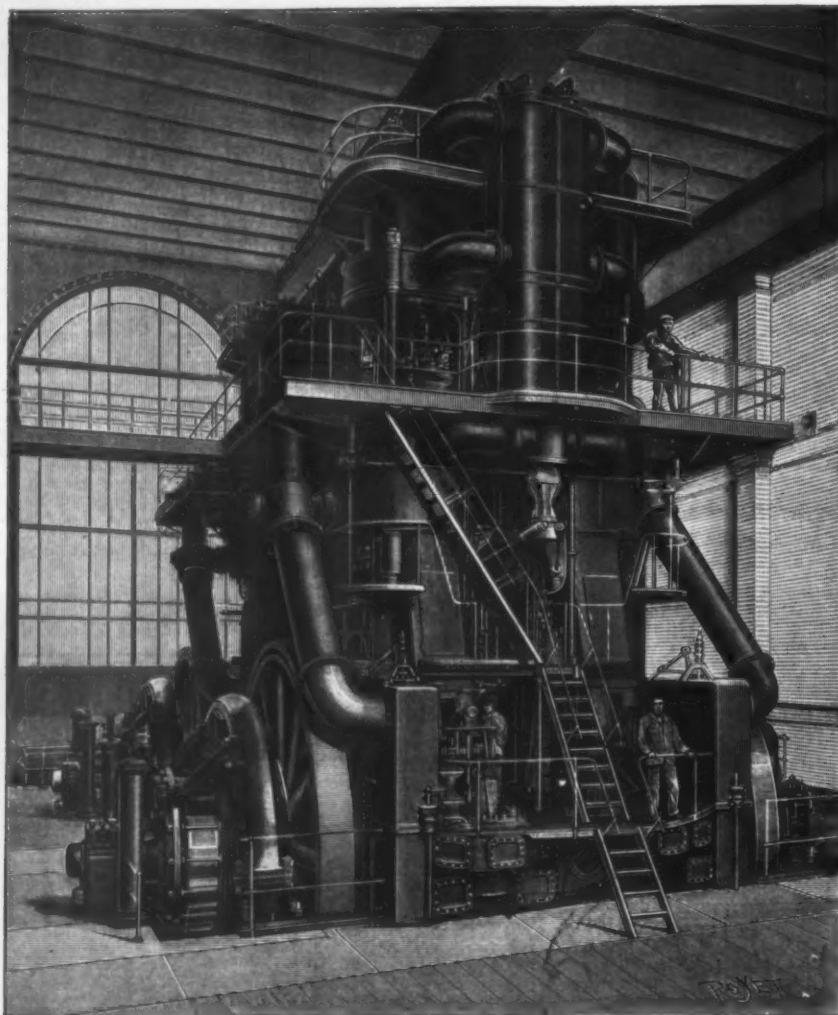
Hammers.—Since the mechanism employed for utilizing compressed air to secure a percussive action is essentially the same in both hammers and riveters, it will be sufficient to describe the mechanism in one of them only, and for this purpose the hammer will serve. Hammers may broadly be divided into two types, viz., the valveless hammer and the valve hammer. This is a convenient description, yet perhaps not strictly correct, because although the valveless hammer has no valve beyond the striking piston, this is itself a valve to effect the proper admission of air to alternate ends of the working cylinder; while in the valve hammer a reciprocating valve, working either at right angles to or parallel with the striking piston, acts in combination with it to regulate the inlet and exhaust of the compressed air. Before coming to a description of these, it may be interesting to set forth the advantages and otherwise of the two systems.

Valveless hammers have essentially a short stroke, and, although economical in air consumption in relation to the number of blows given, they will not compare with valve hammers in giving powerful blows which are necessary in heavy chipping or riveting. Owing, however, to their simple construction, they have probably a longer life than the valve hammers, and for such purposes as beading flues, light caulking and chipping, and especially carving in stone, etc., they compare very favorably with their rivals. The speed of the valveless hammers is very high, being 10,000 to 20,000 strokes per minute.

Valve hammers will probably secure the market for general and heavy chipping, caulking, and riveting. Their speed for ordinary work ranges from 1,500 to 2,000 blows per minute, although they can be driven much faster. Their stroke, however, is considerably longer than that of the valveless hammers and the blow struck correspondingly greater. There is more air lost in the ports, but other advantages, including better control for using the air expansively, overcome this small defect. It is well known that the nature of a blow—whether light or heavy—on various materials, produces an effect apart from the actual work done as measured in foot-pounds. For example, 10,000 small blows representing a certain number of foot-pounds might fail to produce a desired result, which a smaller number of heavy blows, representing less energy in foot-pounds, might effect. Having now considered the claims and advantages of the different types of hammers, all of which it may be stated can be worked economically at from 60 pounds to 80 pounds per square inch, reference must be made to the illustrations in order to explain their construction and action under compressed air.

"Ross" hammer.—Fig. 1, shows in section a "Ross" hammer in which the striking piston becomes the valve to control the admission and exhaust of the working fluid. A represents the outer casing, made from solid drawn steel tube, bored and fitted with a phosphor-bronze liner, B, which forms the cylinder in which the piston works; E, the striking piston made from a steel forging, ground to fit the cylinder; D the exhaust ports, open to the atmosphere through the valve, G; C and C' the admission ports, admitting live air to alternate ends of the piston; K, another port always open to the air supply; G the exhaust valve; H, the trigger actuating the same; F, the phosphor-bronze handle, to which live air is admitted at the point F'; L, a piston cushion, has always full and constant pressure behind it from the air supply through the port, L'; and M shows the working tool.

It must be noted that this hammer is caused to work by the opening of the exhaust and not by regulation of the admission. The direction taken by the fluid under pressure when connected to the handle at F', will be readily seen by noting the arrows. The piston is slightly reduced in diameter in the middle, and the inside edges of the two collars thus produced form the cut-off edges for pressure, while their outside govern the exhaust ports. It will be readily seen that when



3,000 HORSE POWER STEAM ENGINE OF THE ELECTRIC CENTRAL STATION OF LUISEN STRASSE, BERLIN.

as the Optical Palace, with its great telescope, the marcomans, the various panoramas, the pavilions of costumes, etc. The great Globe Céleste is reached by a bridge over the Avenue des Sufferis, and it was this bridge which collapsed shortly after the opening, resulting in the death of several persons. The Pont d'Iena has been widened in an ingenious manner so that access is gained to the last section of the exposition, the Trocadero group, the Palais du Trocadero being a permanent building left after the exposition of 1878. The space between the Trocadero and the Seine is given up to colonial exhibits, which include the pavilions of Egypt, Algeria, Siberia, Cambodia, Japan, Tunis, Transvaal, Soudan, etc. On the whole it is safe to say that the Paris Exposition worthily crowns the conclusion of the century, and the administration authorities deserve the greatest possible credit for the wonderful work which they have done. They have had to contend with many difficulties such as labor troubles, the possibility of obtaining the enormous amount of iron and steel required at the time promised by the contractors and by a plaster of Paris famine. These causes in themselves are sufficient to explain why the buildings are not complete. As for the exhibits, there is also considerable confusion, owing to the difficulty of obtaining transportation in installing them.

We are indebted for our engravings to *L'illustration* and *Illustrazione Italiana*, and for our plans and the foregoing particulars to *Engineering*.

cylinders and slides. The driving shaft is 1.44 feet in diameter and is in two parts connected by bolted flanges.

Each of these parts carries a fly-wheel, 19.68 feet in diameter. The prolongations of the shaft rest in pillow blocks that may be regulated in three directions. The distribution to all the cylinders is effected through balanced valves with four narrow conical seats placed directly upon the cylinder bottoms. These valves are controlled by eccentrics keyed upon a distributing shaft. The admission to the high pressure cylinder is obtained through a Sulzer eliek. The steam, upon making its exit from the cylinder bottom, passes into the jacket of the latter. All the cylinders have steam jackets except the high pressure one, for which superheated steam has to be employed. The distributing shaft is controlled by a vertical shaft that carries the governor and is set in motion by the driving shaft by means of skew spur-wheels. The engineer stands upon a platform at the level of the distributing shaft, whence he can effect all the maneuvers.

At the normal angular velocity of 85 revolutions a minute, and with an admission pressure of 13 atmospheres, these engines are capable of furnishing 1,740, 2,270, 2,800, 3,330 and 3,860 horse power for respective admissions to the small cylinder of 0.11, 0.18, 0.24, 0.33 and 0.50.

Each engine directly actuates two 16-pole continuous current dynamos constructed by the *Allgemeine Electricitäts Gesellschaft* of a normal power of 1,000

the piston is in the middle of its stroke there is a dead point, the live air only finding admission to the chamber formed by the reduced portion of the piston, since the ports, *C* and *C'*, are all cut off from admission of live air, but this does not interfere with its proper working, as the cover is very small. Moreover, when starting, the piston will fall either to one end of the cylinder or the other by gravity, and when at work the momentum carries it over the dead point. The diagram shows the front exhaust valve open, and the piston just commencing to make its forward stroke. Air flows through *K* thence through *C*, passing between the annular space formed between the liner and the outer casing, and back through *C'* to back of piston, thus driving it forward. At the same time, exhaust takes place through *D*. The same action takes place on the rearward stroke, when the forward ports, *C* and *C'*, are then in communication with *K*. In order, as far as possible, to eliminate vibration, a condition which is present in all hammers, the cushion piston, *L*, has been introduced at the rear of piston.

"Q and C" hammer.—Fig. 2 shows in section a "Q and C" single hammer. *A* represents a bronze handle, in which is fitted the steel liner, *B*, which forms the working cylinder; *C*, the striking piston, which acts as its own valve; *D*, the outer cap, connecting the liner to the handle; *E*, the throttle valve; *F*, the trigger actuating same; and *G*, the point to which the air supply is attached. The action of the hammer on the tripper being depressed is as follows:

The air having passed the valve, *E*, flows along the passage, *d*, and through a large air port into the cylinder or pressure chamber; this has the effect of maintaining a constant pressure under the shoulder of the piston and tends to drive it backward. When, however, the ports, *b*, in the piston, *C*, which are also large openings, come into communication with the cylinder, the pressure fills the hollow portion of the piston and the cylinder in its rear, driving the piston forward to strike its blow. At this instant, however, the piston ports come into communication with the exhaust port, *c*, when the pressure under the piston shoulder again returns the piston, and the blows are repeated in rapid succession—it is stated as many as 10,000 to 20,000 per minute. It will be noticed that in this arrangement of ports the air is used expansively. The same type of hammer is made in a modified form, being provided with a second piston placed in the rear of the other, the actuating fluid working between the two pistons for the forward stroke. It is claimed for this that vibration is reduced to a minimum. Coming now to the valve hammers, to briefly and the same time accurately describe them is not an easy matter, because although they are simple in action and not excessively complicated with regard to the number of working parts, yet their movements and arrangements of parts is such as to make their description somewhat difficult. The au-

ber; *a'*, passage from front end of cylinder to annular space, *e'*, in valve chamber; *a''*, exhaust passage at rear end of cylinder leading to exhaust through interior of valve; *a'''*, bye-pass from *a'* to cylinder; *a''''*, bye-pass from cylinder to *a'*; *a'''''*, exhaust passage in forward end of cylinder to atmosphere; *b*, reduced portion of striking piston; *b'*, annular chamber formed by such portion; *c*, opening into the controlling valve bushing; *c'*, opening into cylinder from valve bushing; *c''*, cap on top of valve bushing; *c'''*, annular portion in valve bushing; *c''''*, openings in valve, *E*, leading to ex-

"Little Giant" Hammer.

Piston and Valve in extreme positions.

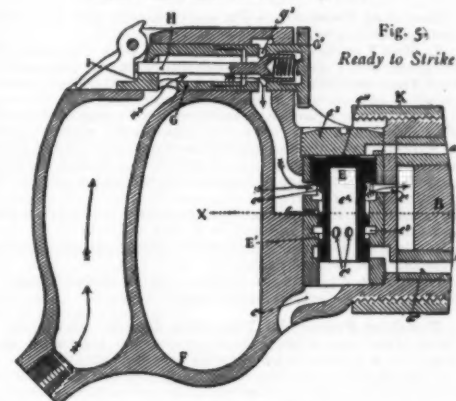


Fig. 5.

Ready to Strike

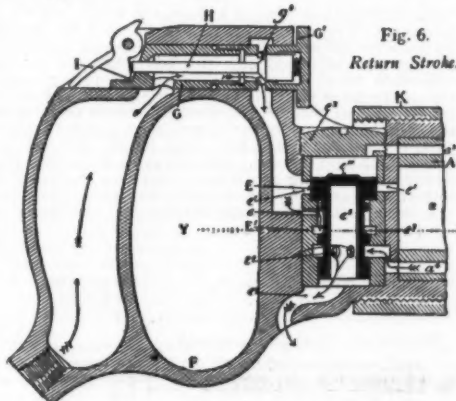


Fig. 6.

Return Stroke.

haust port, *e'*; *e''*, central chamber of valve; *e'''*, exhaust to air in handle; *e''''*, enlarged diameter of valve for cushioning; *e'''''*, recess behind *e''*; *e''''''*, small boss on top of valve. Fig. 3 represents a longitudinal sectional elevation of a hammer with the striking piston at the rear end. Fig. 4 is a similar view, but of the opposite half, and showing the striking piston at the forward end of stroke. Figs. 5 and 6 show the handle and valve portion in section with the valve at the top and bottom positions respectively. Figs. 7 and 8 show horizontal sections taken on lines *X* and *Y* of Figs. 5 and 6 respectively.

The action of the tool is as follows: Fluid under pressure having been admitted by operating the valve, *H*, passes through the opening, *e*, and under the head of the valve, *E*, thus forcing it in the position shown in Fig. 5. The air is then able to pass into the cylinder through the opening, *e'*, and this forces the piston forward into the position shown in Fig. 4. It will be noted that the piston is reduced in diameter at *b*, which together with the cylinder forms a chamber, *b'*, so that as the piston nears its forward limit of stroke, fluid pressure enters the chamber, *b'*, from the passage, *a'*, which is in direct communication with space, *e*. At the same time the passage, *a'*, is brought into communication with *b'*, and thus the air passes along to the top of the valve, *E*, and forces it into the bottom position, as shown in Figs. 3 and 6. When the valve is in this position a clear way for the compressed air is open to the front end of piston through *e*, *e'* and *a'*, thus effecting the return of the piston. Thus far the live air admission has been dealt with to drive both piston and valve in both directions. Coming now to the exhaust and taking the piston in its rearward motion first, the air escapes along the passage, *a'*, and through the openings, *e'*, in valve and out through *e''*. In its forward motion the piston exhausts first through *a'*, which leads direct to outer atmosphere—see Fig. 4. When *a'* is passed, the air escapes through *a''*, which is open to atmosphere through *e'*, *e''* and *e'''*, when the valve, *E*, is up. The exhaust of the valve is effected thus: During the backward movement of the piston, and as its annular portion is passing *a'*, it permits the fluid pressure on top of valve, *E*, to escape through *a'*, *a''* into *b'*, *a'* and *a''*, to atmosphere, with the result that superior pressure under valve head from *e* again lifts the valve. The valve is forced into its bottom position due to its area on the top being larger than the ring underneath its head. It is obvious that both the striking piston in its backward stroke and the valve in both directions should receive some form of cushioning, so as to reduce shock and prevent injury to valve and cylinder. In the piston this is effected by its closing the port, *a'*, before the end of its stroke. In the valve the desired cushioning is secured in its upward stroke by means of the boss, *e''''*, which causes the air to escape rather slowly into *a'*. In its downward stroke the cushioning is effected thus: The portion, *e'*, of the valve, *E*, is of a diameter nearly equal to the small bore of the valve bushing, and there is also provided a small groove, *e''*, Fig. 5. When the valve is moving down, the portion, *e'*, first enters the small bore of the valve chamber, and this tends to retard the

passage of the air through the bore, and permits the excess of air to act as a cushion. Up to a certain limit the same hammer may be used to give light or heavy blows, and this may be effected by regulating the amount of opening given to the throttle valve. It is not desirable, however, to simply rely upon the trigger to do this, but preferably to provide a regulator, so that however hard the trigger may be pushed it only opens the valve the desired amount. In the "Little Giant" hammer this result is obtained by making the throttle valve bushing in two portions, *G* and *G'*. The part *G* is fixed to the handle, while *G'* is capable of being screwed in or out. The effect of this adjustment, when taken in combination with the valve, *H*, and the trigger, *I*, is such that when *G'* is unscrewed, the port, *g'*, may be moved into such a position that the valve, *H*, can be pushed by the trigger, *I*, to the limit of its stroke without uncovering the port, *g'*, at all, and by adjustment of the part, *G'*, any desired opening may be given for the admission of air. In order to put the valve, *H*, in equilibrium a small opening admits the compressed air to either side of it, which, together with the spring shown, effects the desired result. It will be obvious that fewness of parts, and especially of joints, are desirable in the construction of a tool using compressed air at high pressure, since the possibility of leakage is thereby considerably reduced. The question of joints is of necessity more difficult to deal with in a valve hammer than with a valveless hammer, but in the "Little Giant" type this danger has been reduced to a minimum, by dispensing with a valve block and inserting the valve bushing direct into the handle, while the cylinder portion, *A*, is securely fixed to the handle, *F*, by means of a sleeve, *K*. Another feature of this hammer is the economical use of the compressed air, due to the cushioning of the moving parts taking place on the exhaust air rather than from the admission of live air, and taking this in connection with the solid construction of the valve, the same being well cushioned in both directions of its travel, the "Little Giant" type, Fig. 8, is likely to prove both an economical and a good wearing hammer.

"Boyer" Hammer.—Figs. 10 to 15 show several sectional views of a Boyer hammer, in which the following letters of reference indicate the various parts referred to: *A*, the working cylinder; *B*, the handle; *G*, the air passage from throttle valve to cylinder; *G'*, throttle valve; *H*, trigger actuating same; *I*, the valve block; *I'*, cap at end of same; *K*, the working tool; *M*, the piston, consisting of a solid piece of turned steel fitting the bore of the cylinder and provided with a recess, *M'*; *O*, the valve; *P*, passage from cylinder to small space, *e*; *Q*, passage from cylinder to small space, *n*; *R*, passage from front end of cylinder to small space, *m*; *S*, port leading from space, *e*, to front of cylinder through passage, *R*; *T*, passage from cylinder through *U* to space, *e*; *T'*, from air supply to cylinder; *X*, from air supply to *e*.

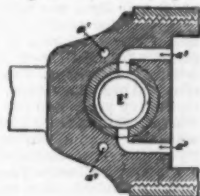
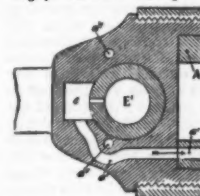
It is only necessary to supply fluid to front end of piston via *S* and *R* and to hold the valve in rear position. Other letters on the drawings are referred to in the following description of the working of the hammer:

Figs. 10 and 12 represent the piston in its forward and the valve in its rearward position. The motive fluid having been admitted, passes along the passage, *G*, and then through *W* into space, *e'*, and acts on small area, *d*, of the valve, *O*, and tends to force the valve forward, but fluid pressure in space, *e*, admitted by the

"Little Giant" Hammer.

Fig. 7. Section at X, Fig. 5.

Fig. 8. Section at Y, Fig. 6.



"Boyer" Hammer.

Fig. 10.



Fig. 11.

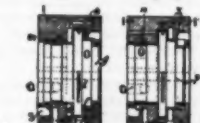


Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.



thor has, however, endeavored to be as brief as possible, while at the same time referring to their essential features.

"Little Giant" Hammer.—This is illustrated in Figs. 3 to 8, to which the following key applies: *A*, working cylinder; *B*, piston hammer; *D*, working tool; *E*, controlling valve; *E'*, steel seating for same; *F*, handle; *G* & *G'*, throttle valve bushing; *H*, throttle valve; *I*, trigger actuating same; *a*, bore of cylinder; *a'*, passage leading from space, *e*, to the cylinder, and always full of fluid pressure when throttle valve is open; *a''*, passage leading from cylinder to top of valve cham-

ber, *a'*, passage from front end of cylinder to annular space, *e'*, in valve chamber; *a''*, exhaust passage at rear end of cylinder leading to exhaust through interior of valve; *a'''*, bye-pass from *a'* to cylinder; *a''''*, bye-pass from cylinder to *a'*; *a'''''*, exhaust passage in forward end of cylinder to atmosphere; *b*, reduced portion of striking piston; *b'*, annular chamber formed by such portion; *c*, opening into the controlling valve bushing; *c'*, opening into cylinder from valve bushing; *c''*, cap on top of valve bushing; *c'''*, annular portion in valve bushing; *c''''*, openings in valve, *E*, leading to ex-

end of the passage, *P*, will be uncovered by the front end of the piston at the same time as the front end of the passage, *Q*, and the fluid in space, *e*, will escape through passages, *P* and *Q*, groove, *n*, and passages, *o*, *i*, *j*, *k*, to the outer air. Passage *P* being larger than passage *Q*, by which the fluid is supplied to the space *e*, the pressure on the large area, *c*, of the valve, *O*, will be greatly diminished, so that the pressure acting on the small area, *d*, of the valve, *O*, will force the valve forward to the position of Figs. 11 and 13, whereupon the ring, *b*, of the valve, *O*, will close the passage, *X*, and cut off the supply of fluid to space, *e*, thereby permitting pressure at *d* to hold the valve in the forward position. The annular space, *p*, will now be opened, from which fluid pressure via *W* and *e'* will pass to the interior of the valve, and acting on the rear end of the piston will first bring it to rest, forming a cushion, and later drive the piston forward. As the piston moves forward and finally strikes a blow on the chisel the air in front can escape through passage *Q* until the latter is closed by the front end of the piston, and thereafter can escape through passage *R*, grooves *m*, *a* and *n*, and passages *o*, *i*, *j* and *k*, to the atmosphere. When the piston is moved so that *T* and *T'* are in communication via groove, *M'*, fluid under pressure will pass via *T*, *M'*, *T'* and *U* to space, *e*, and acting on the large area, *c*, of the valve, *O*, will overcome the constant pressure on its small area, *d*, and force the valve backward, and thus open *X*, admitting more fluid to space, *e*, to hold the valve in that position; also fluid will pass from *e* to *R* via *S* and to the front end of the piston to assist in driving the piston back. The recoil accomplishes most of the return of the piston. During the backward movement of the piston, the end of the cylinder is open to exhaust through slots, *l*, in the valve, *O*, and groove, *A*, and passages, *i*, *j*, *k*, until the passages, *P* and *Q*, are uncovered by the front end of the piston, at which time the valve opens, and, admitting fluid, arrests the piston and drives it forward. Although communication between *T* and *T'* is cut off almost directly the piston commences its backward movement, the valve, *O*, will not change its position—from rear to front—because sufficient fluid pressure is passing into space *e* through passage *X* to hold the valve, notwithstanding the escape of the fluid via *S*, since the latter is of less capacity than *X*. It will be readily understood that the action of the compressed air along the passage, *Q*, acting first on one area and then on another area of the valve, *O*, drives it in alternate directions, and that the valve in turn admits air to either end of the cylinder; at the same time the piston opens and closes certain ports in the cylinder, as in the case of the valveless hammer, and the combination of the dual motions of the valve and the piston produces the desired result of causing the piston to rapidly reciprocate and deliver a number of blows upon the tool, *K*. In this hammer it will be noted that the striking piston passes through the valve, which has the effect of increasing the stroke of the piston as compared with the original design of the hammer, in which the valve was arranged in a separate chamber immediately in the rear of the piston chamber, and without increasing the overall length. In order to effect a cushion on the piston on the rearward stroke live air is admitted before such stroke is completed. With regard to the valves, owing to their extreme lightness and shortness of stroke, it is stated that cushioning of the valve is unnecessary.—The Engineer.

ELECTRO-CULTURE.

THE results obtained by culture under the influence of electric light are fairly well known, and the growing of lettuce for salads, in spacious greenhouses with the aid of electric light, is already a profitable industrial pursuit in the United States (near Chicago and elsewhere). However, the use of electric currents for stimulating vegetation, although it was studied more than fifty years ago (by Ross, in 1844-46; continued by Foster, Sheppard, Fichtner, etc.), still remains unsettled. A communication upon this subject, made by a Russian engineer, V. A. Tyurin, before the St. Petersburg Electro-Technical Society, contains some welcome information upon the work done in this direction in Russia by M. Spysheff and M. Kravkoff. The former experimented a few years ago on three different lines. Repeating well known experiments on electrified seeds, he ascertained once more that such seeds germinated more rapidly, and gave better fruit and better crops (from two and a half to six times higher) than seeds that had not been submitted to preliminary electrification. Repeating next the experiments of Ross—that is, burying in the soil one copper and one zinc plate, placed vertically and connected by a wire, he found that potatoes and roots grown in the electrified space gave crops three times heavier than those which were grown close by on a test plot; the carrots attained a quite unusual size, of from ten to twelve inches in diameter. Spysheff's third series of experiments was more original. He planted on his experimental plot, about ten yards apart, wooden posts provided at their tops with metallic aigrettes connected together by wires, so as to cultivate his plants under a sort of network of wires. He obtained some striking results, one of which was that the growth and the ripening of barley were accelerated by twelve days. Quite recently M. Kravkoff undertook a series of laboratory experiments upon boxes of soil submitted to electric currents. The temperature of the soil was raised by these currents; its moisture decreased first, but began to increase after a course of three weeks (the same increase of moisture was also noticed by Fichtner); and finally, the amount of vegetable matter in the soil was increased by the electric currents. With what is now known upon the influence of micro-organisms upon vegetation, further research on similar lines is most desirable and very promising.—Nature.

Nicotiana soap is made from the spent lye waters remaining in the vacuum at the cigar factories. The water is inspissated at the factories in the vacuum to the consistency of extract. This extract, mixed with milk of sulphur and superfatted soap paste, and scented with bergamot oil, gives a brown soap. The proportions of the ingredients in the soap are as follows: Tobacco extract, 5 per cent.; milk of sulphur, 5 per cent.; and superfatted soap paste, 90 per cent. It is used for scabies and skin diseases.—Pharmaceutische Post.

TRADE NOTES AND RECEIPTS.

Petroleum Insecticide.—Soft soap and warm water mixed in equal parts, and made into an emulsion by thoroughly stirring with petroleum, is said to give, diluted for use with water, an excellent remedy against parasites.—L'Union Pharm.

Putz Pomade.

Oleine..... 40 kilogrammes.
Ceresine..... 5 "
Trioli..... 40 "
Light mineral oil (0.870)..... 30 "
Melt the oleine, ceresine and mineral oil together, and stir in the trioli; next, grind evenly in a paint mill.
—Seifensieder Zeitung.

Insulating Varnishes.—For earth cables and exposed strong current wires:

1. Melt 2 parts of asphalt together with 0.4 parts of sulphur, add 5 parts of linseed oil varnish, linseed oil or cotton seed oil, keep at 160° C. for 6 hours; next pour in oil of turpentine, as required.

2. Maintain 3 parts of elaterite with 2 parts of linseed oil varnish at 200° C. for 5 to 6 hours, next melt 3 parts of asphalt, pour both substances together and again maintain the temperature of 200° C. for 3 to 4 hours, and then add 1 part of linseed oil varnish and oil of turpentine as required.

Insulating varnish for dynamos and conduits with low tension:

1. Shellac, 4 parts; sandarac, 2 parts; linoleic acid, 2 parts; alcohol, 15 parts.
2. Shellac, 4 parts; sandarac, 4 parts; elemi, 1 part; alcohol 20 parts.—Farben Zeitung.

Polishing Powder for Fine Steel Goods.—Der praktische Maschinen-Constructeur, gives the following receipt for a polishing powder for fine steel articles.

Take equal parts, (by weight), of ferrous sulphate—green vitriol—and sodium chloride—cooking salt—mix both well together by grinding in a mortar and subject the mixture to red heat in a mortar or a dish. Strong fumes will develop, and the mass begin to flow. When no more fumes arise, the vessel is removed from the fire and allowed to cool off. One has obtained a brown substance with shimmering scales, resembling mica and of the same appearance as iron glance. The mass is now treated with water, partly in order to remove the soluble salt, partly in order to wash out the lighter parts of the non-crystallized oxide, which yield an excellent polishing powder. The fire must be neither too strong nor too long continued, otherwise, the powder turns black and very hard, losing its good qualities. The more distinct the violet-brown color, the better is the powder.

Mouth Washes.

Quilla bark..... 125 grammes.
Glycerine..... 95 c.cm.
Alcohol..... 155 "

Macerate for four days and add:

Acid. carbol. cryst..... 4 grammes.
Ol. Geraniol..... 0.6 c.cm.
Ol. Caryophyll..... 0.6 "
Ol. Rose..... 0.6 "
Ol. Cinnamon..... 0.6 "
Tinct. Ratanhia..... 45 "
Aqua Rose..... 900 "

Macerate again for four days and filter.

Thymol..... 20 parts.
Peppermint oil..... 10 "
Clove oil..... 5 "
Sage oil..... 5 "
Marjoram oil..... 3 "
Sassafras oil..... 3 "
Wintergreen oil..... 0.5 "
Cumarin..... 0.5 "
Alcohol dil..... 1,000 "

A teaspoonful in a glass of water.—Deutscher Drogeristen Zeitung.

The Opium Production in Persia.—The best opium is known to be produced in the countries of the Orient, although attempts have not been lacking to cultivate it in Europe as well. The best grade is probably that produced in Persia, and a short description of the mode of culture there may be of interest.

Persia exports annually 6,000 cases of opium, weighing about 130 pounds each, and the home consumption is said to be as large. The poppy used there for cultivation is an especially large-flowering variety. Although the plants require no particular soil, they demand very carefully and evenly regulated watering, upon which the quality of the opium mainly depends. The sowing of the poppy fruit is performed in September or October, after the ground has been well ploughed, carefully freed from stones and rolled smooth. The poppy seed is thrown out on the smooth surface of the soil and the ground thoroughly moistened with water, whereupon the fields are left alone for a few days. Next, sand is sprinkled on the surface and the latter is pressed down firmly and smoothed. In a few weeks the fields exhibit a rich green and the young plants, if they have come up strong, do not suffer any damage, even if the temperature should once in a while sink below zero (C). The flowering period, which lasts about fourteen days, commences in May, and after it has ceased there commences for the opium grower the time of the most arduous work, requiring the greatest attention, since the cutting into the unripe poppy capsules, which is now necessary, has to be carried out in strict accordance with their development. If it is done too early a white sap, yielding no opium, flows out, while on the other hand the capsule become dry as soon as the right moment is allowed to pass. The incisions, of which two are made crosswise and vertically, are usually performed in the evening. If the correct moment is hit, the exuding sap shows the yellow color of amber. The solidified exudation is taken off before sunrise and gathered in an earthen vessel, until the whole crop is completed. Naturally, this crude opium is very impure, being mixed with parts of leaves, husks, etc., and is in this condition brought up by persons who conduct the purification and preparation into a commodity, consisting in kneading with water and a little oil, whereby the foreign ingredients are removed.—Technische Notizen.

SELECTED FORMULÆ.

A Good Table Sauce.—The following formula, if properly prepared, will make an elegant table sauce. It has been in use by the writer and numbers of his friends for many years, and has given universal satisfaction:

Allspice.....	2 parts.
Cloves.....	1 "
Black pepper.....	1 "
Ginger.....	1 "
Cayenne.....	1 "
Mustard (English).....	16 "
Salt.....	16 "
Shallots.....	16 "
Brown sugar.....	32-64 "
Tamarinds.....	32 "
Curry powder (East Indian).....	9 "
California sherry.....	130 "
Garlic, at discretion, q. s.	
Best malt or cider vinegar, q. s. to make 500 parts.	

Powder the spices, etc., mix the ingredients, and simmer gently together in a porcelain-lined vessel for 1 hour, adding vinegar from time to time to make up the loss by evaporation. Do not, under any circumstances, allow the mixture to come to a boil, as this would spoil the delicacy of flavor of the sauce. Remove from the fire, let stand for a week, or until clarified, then add sufficient caramel to give the desired depth of color, rack off and bottle. In regard to garlic, while a pronounced flavor of it is disagreeable to many—perhaps the majority of Americans, a mere soupçon of it is relished by everybody—even those who protest that they "cannot bear the stuff." Probably one large clove, or two small ones, to every gallon of sauce will be quite sufficient to give the requisite flavor. If the foregoing is too costly, you can, by the exercise of a little discretion, modify it considerably in this direction. You are at liberty to manufacture and offer this for sale under any name, not already appropriated, you please. The formula for table sauces, etc., are trade secrets, some of them of great value, peculiarly known only to the proprietors or their trusted employes, and outsiders have no honest method of becoming acquainted with them. Analysis is powerless in solving the question, and the so-called "formulæ" for such articles, appearing in the trade journals, are the merest fakes, intended, at best, to imitate external appearances, without regard to the valuable qualities of the originals. They are doubly fraudulent, as they are intended to deceive the credulous manufacturer, as well as the general public, and to injure the manufacturers of genuine articles.—National Druggist.

Washing Powders.—G. Mexico.—Most washing powders, it is said, consist of sodium carbonate (the sal soda of commerce) and soap, the proportions varying from nearly equal parts, the carbonate predominating, to two of the carbonate to one of soap. The following formulas for variations of this type have been given in The New Idea:

1. Sodium carbonate, partly effloresced.....	2 parts.
Soda ash.....	1 "
2. Sodium carbonate, partly effloresced.....	6 "
Soda ash.....	3 "
Yellow soap.....	1 "
3. Sodium carbonate, partially effloresced.....	3 "
Soap bark.....	1 "
4. Sodium carbonate, partially effloresced, Borax, Yellow soap, equal parts.	

The following directions are given in an article on this subject in Der Seifenfabrikant:

"A very good powder can be made from 100 parts of crystal soda, 35 parts of dark yellow resin cured soap, and 5 parts of soft soap. The two latter are placed in a pan, along with one-half the soda (the curd soap being cut into lumps), and slowly heated, with continual stirring, until they are thoroughly melted—without, however, beginning to boil. The fire is then drawn and the remaining soda crutched in until it too is melted, this being effected by the residual heat of the mass and the pan. The mass will be fairly thick by the time the soda is all absorbed. After leaving a little longer, with occasional stirring, the contents are spread out on several thin sheets of iron in a cool room, to be then turned over by the shovel at short intervals, in order to further cool and break down the mixture. The soap will then be in a friable condition, and can be rubbed through the sieve, the best results being obtained by passing through a coarse sieve first and one of finer mesh afterward.

"With these ingredients a fine yellow-colored powder will be obtained. White stock soap may also be used, and, if desired, colored with palm oil and the same colorings as are used for toilet soaps. The object of adding soft soap is to increase the solubility and softness of the powder, but the proportion used should not exceed one-third of the hard soap, or the powder will be smeary and handle moist. The quality of the foregoing product is good, the powder being stable and not liable to ball, even after prolonged storage; neither does it wet the paper in which it is packed, nor swell up, and therefore the packets retain their appearance.

"In making ammonia turpentine soap powder the ammonia and oil of turpentine are crutched into the mass shortly before removing it from the pan, and if the powder is scented—for which purpose oil of mirbane is mostly used—the perfume is added at the same stage."

According to Jolles washing powder is also made by mixing carbonate and thiosulphate of sodium. The composition of a sample is given as: Sodium carbonate, 68.5; sodium thiosulphate, 5.73; water, 23.37; sodium sulphate, 1.04; sodium chloride, 0.89; iron oxide, etc., 0.47.—Druggists' Circular.

Lactic Acid for Baldness.—Balzer recommends lactic acid as a remedy against baldness. He rubs the bald spots daily with a 30 per cent. lactic acid solution until the skin becomes inflamed. The embrocations are then stopped for a few days, but continued as soon as the inflammation has disappeared. Balzer observed hair growing again on the spots after three weeks' treatment.—Apotheker Zeitung.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Sugar as Food.—In Grandea's pamphlet entitled "Le sucre et l'alimentation de l'homme et des animaux," Paris, 1899, the following estimate of the world's sugar production is given:

	Tons.
Cane sugar.....	2,432,000
Beet sugar.....	4,822,000
Total.....	7,254,000

Nearly one-fourth of all the sugar produced is German beet sugar, which amounts to 1,700,000 tons annually, says Consul George H. Murphy of Magdeburg. Of this German production, more than one-half is exported, and accordingly the price is dependent upon sugar consumption in other countries and the demand in the world's markets. The growth of the beet-sugar industry in the United States and the increase of production in other parts of the world are already causing anxiety in Germany. The calm and intelligent German mind is accordingly now busy with investigations upon the results of which plans can be based for preserving a healthy equilibrium between consumption and production, and thus protecting industries in which millions of Germans have a vital interest.

Many elements of uncertainty enter into the question of how to restrict the increase of production. Moreover, as far as foreign countries are concerned, it would be useless to waste time in discussing this question.

The questions, therefore, which Germans are now considering are these:

There is a large overproduction of sugar in Germany, which at present makes exportation an absolute necessity. Will natural causes maintain this foreign demand for German sugar? and can Germany's overproduction be decreased by increasing the consumption of sugar at home?

The use of sugar began in the Orient and gradually spread to Europe and America. The quantity used per capita is constantly and everywhere increasing, as is shown by the following table:

Country.	1870-1875.		1885.		1897.	
	Kilo-grams.	Pounds.	Kilo-grams.	Pounds.	Kilo-grams.	Pounds.
Great Britain.....	32.6	49.8	32.6	50.1	38.9	59.7
America.....	16.3	24.9	21.5	32.3	28.3	42.5
France.....	7.8	11.7	10.7	16.1	13.9	20.6
Germany.....	6.7	10.1	7.8	11.7	12.1	18.2
Austria.....					8.9	13.4
Russia.....					4.9	7.4

Owing to the growth of the sugar-using population, the total increase in the amount consumed is much larger than is indicated by the gain per capita.

The increase of consumption is shown by the following table:—

Country.	Increase from 1874 to 1897.	
	Total.	Annual.
	Per cent.	Per cent.
Great Britain.....	90	3.5
America.....	278	12.1
France.....	142	6.18
Germany.....	157	6.91
Austria.....	107	4.65

Unless, therefore, the world's production be very much increased, it is probable that the demand for German sugar will at least remain stationary.

But the German prefers to be ready to meet any emergencies which may arise. It is always possible that the foreign demand for German sugar may be lessened by increased production abroad, by measures growing out of international custom, and by other unforeseen causes. Furthermore, the amount of sugar which must be exported may be increased by the extension of beet culture in Germany. The protection of this great industry and of the people dependent upon it, therefore, demands a large increase in the home consumption. The table given above shows that the amount of sugar used in Germany per capita is rapidly growing, but it is realized that this growth must be encouraged and largely accelerated. This can be done in two ways—namely, by increasing the manufacture and exportation of preserves, marmalades, etc., and by increasing the amount of sugar used by individuals, especially in the army, where increased consumption may be made compulsory. The question of increasing the manufacture of preserves is a practical one, which does not require consideration here.

But before raising the amount of sugar to be used by individuals, German scientists have investigated the question as to whether this can safely be done. They have decided that the amount of sugar used by individuals can be increased without hesitation, as sugar has many valuable characteristics. Its value lies not alone in its sweetness, but in the fact that it is a valuable dietetic remedy and an excellent article of food. Sugar is a very easily soluble carbon hydrate and as such is quickly assimilated in human and animal bodies, producing warmth and force. It is also fattening and can be used as mast. As a developer of strength, it has long been used, especially by mountain climbers. Various experiments have been made for the purpose of ascertaining whether sugar can be advantageously used for fattening animals. The results have proved favorable as far as hogs are concerned. It has been found that by-products of sugar fabrication, denaturalized and free of tax, can be advantageously used as food for hogs. Molasses, which contains about 50 per cent. of sugar, is already much used mixed with palm flour or peat, as cattle food.

The principal objects of the experiments has, however, been to ascertain positively whether, as alleged, sugar possesses the power of quickly increasing or restoring strength and thereby making men fit for unusual exertion. This point has been carefully investigated, the scientist not watching the entire muscular action of a man because that would have been too difficult, but confining himself to observing a single finger through an instrument called an ergograph—i. e.,

"work measurer." He allowed the middle finger of the right hand to lift a weight, and then registered the degree of the lifting force. The experimenter found that after sugar had been eaten the lifting force was stronger than before, and he, therefore, concluded that sugar is a strength-producing material.

Other investigators claim, however, that sugar has merely an exciting effect through its sweet taste, and that a ducine solution, which contains no carbon hydrate and accordingly cannot be nourishing, has the same effect as sugar water. The inference from this is that the assertion that sugar produces strength is a fallacy.

This disappointing experiment has, however, been repeated by two scientists, and the same result was reached when the man experimented upon had his full strength; but the effect of eating sugar was found to be entirely different when the man had first tired himself by turning a heavy wheel (ergostat). The eating of sugar brought to the exhausted man new strength, and the ergograph registered increased force, which was not the case when ducine was eaten. It is accordingly accepted in Germany as satisfactorily proven that sugar can renew the strength of a wearied man through giving his tired muscles carbon hydrate as a strengthening material. Extensive experiments have since 1898 been made upon German soldiers at the maneuvers, with moderate success. It is believed that by eating half a dozen cubes of sugar more than usual in a day, a soldier's power of endurance is increased. The Germans at any rate think it worth while to continue to experiment for the purpose of ascertaining positively whether sugar can give renewed strength to exhausted troops, thereby increasing their value in moments of emergency.

If in these ways the domestic consumption of sugar can be enlarged, the overproduction will be lessened, and it is hoped that thus beet culture and the sugar industry will continue to be of great value to Germany in the future.

German Steel-Rail Exports.—Acting Consul Monaghan writes from Chemnitz, February 1, 1899:

Germany's export in steel rails is increasing each year. In 1894 she exported 119,410 tons, worth \$2,356,200. In 1898 it increased to 123,839 tons, worth \$3,094,000. The importation of steel rails into Germany decreased from 8,542 tons in 1894 to 267 tons in 1898.

Eggs, Poultry and Meat in Great Britain.—M. de Loverdo has read before the Société Nationale d'Agriculture de France an article on the importation of eggs into Great Britain, of which The London Times gives, in an issue of recent date, a translation a full column in length, and in turn I use this material, condensing and adopting freely, says Consul Marshal Halstead, of Birmingham.

The importation of eggs into Great Britain last year was valued at \$24,548,237, while the poultry and game figures were \$3,821,633, an outlay of \$28,369,860 in addition to that for the poultry and eggs produced in Great Britain.

M. de Loverdo describes the special cars in use, which are so made that chickens for this market can be fattened during the transport, one attendant being able to take care of a number of cars. Young Russian chickens bought at low prices are thus prepared for the English market and reach here alive, and the same system has been followed with success in Italy. Belgium has been fortunate enough in establishing a specialty, not only for the London market, but also in Paris, with its "petit pousin," for which restaurant keepers in both places willingly pay 48 cents apiece. They are ready for the table in six weeks, the particular breed of Flemish fowls which furnishes these early-maturing chickens being known as the Braekel, which has long been famous for its precocity. French poultry breeders are urged to exhibit the attractive Mans and La Bresse chickens at the Smithfield dead chicken show, held annually in London.

England is credited with but a small production of turkeys, and, in spite of the supplies from the county of Norfolk and, more recently, from Ireland, importations from abroad have increased enormously in late as the liking for turkeys is greatly on the increase in England. The British market is supplied primarily from Italy and France, Canada and parts of Eastern Europe ranking next. M. de Loverdo does not mention the United States as sending poultry to this market. France sends two kinds of turkeys—from Solonge and Normandy, respectively. These used to find a ready market, but lately have found formidable rivals in the Irish turkeys, which are better fattened and cared for. The Normandy turkey is more precocious than the Solonge and fattens very readily. The flesh is juicy and of an exquisite flavor, and commands about 4 cents a pound more. It is suggested that the Normandy turkey might with advantage be introduced into the French midlands. Next to the Norfolk turkey, which occupies the place of honor in the English market, those from France and Ireland are most valued. But more turkeys are received from Italy than from France. The Italian turkeys possess a flavor almost equal to the Normandy birds, though their weight does not often exceed a dozen pounds. France exports annually 60,000 turkeys, while Italy exports from 600,000 to 800,000; but the birds from beyond the Alps find their way not only to London, but to Leipzig, Dresden, Frankfurt, Berlin, and Hamburg, and they realize higher prices in those German towns than in England. During the last two or three years, Canada has made extraordinary efforts to establish a turkey trade in England, the greatest care being bestowed upon the transport in cold storage; but, while these Canadian birds have no lack of quality and easily attain the weight of 20 pounds, it is said the refrigeration they are subjected to does not improve the flavor of the flesh.

But this complaint about refrigeration is always made in Great Britain, and I judge from the statements of those who have made a fair, honest, and unprejudiced trial with refrigerated meat that chilled meat, as opposed to frozen meat, is all right if properly taken care of, if allowed to "thaw" out slowly and not put in the oven while cold. The general objection to it here seems to be based largely on prejudice, and I believe the consumer is not aware of the difference, provided the meat is not delivered cold. An acquaintance tells me that, when in Australia, he sent two lambs to friends here whom he knew would follow

his instructions. He tried to have them arrive so that his friends could enjoy the novelty of spring lamb on Christmas day. They were instructed to allow the carcasses to hang so that they would warm slowly and be at a natural temperature when put in the oven. His friends obeyed with exactness and reported that they never enjoyed better lamb; so that even frozen meat can be used and enjoyed if properly heated, as of course all Australian meat must be frozen in transport on account of the great distance. America, on the other hand, has an advantage in shorter distance; it can transport meat chilled and not frozen. The butchers here claim that in meat which has been frozen, the blood vessels are found to have burst when the meat is cooked. The fact is, the best American meat brought to this market is sold by the butchers—so great is the prejudice against "frozen" meat—as English meat; but it can generally be told by the smaller bones, as we kill younger cattle, while the poorer grades of English meat, are often sold as American meat, and, of course, there are some very poor grades of English meat, for their is so much pedigree cattle of value too great to be killed until beyond the breeding age. It happens to be a fact at present that it is more difficult than formerly to get good meat in England, and if the statements of the butchers of Birmingham, in their recent proclamation announcing a 4-cent-per-pound increase, are to be believed, this is due to the lessening of the American supply, owing to the number of transports employed for South Africa and the amount of meat which must be shipped thither. Of course, the butchers do not confess that the decrease in the American meat supply means a decrease in the supply of good meat, though this is the fact; it has increased the demand of English meat, so that English meat is now "too fresh."

In continuation, M. de Loverdo says that, so far as France is concerned, Canadian competition need not be regarded as disquieting. Hungary and Serbia have furnished some indications of ability to supply the London market with turkeys; but, owing to the great overland distance, the dead birds do not arrive in the best of conditions, while the use of refrigerators would put them in practically the same category as those from Canada.

Geese are less in favor with the British public than formerly; but there is a demand in excess of the home supply, especially at Christmas time, and France reaps this benefit almost exclusively, it being estimated that 100,000 to 150,000 are sold in London in December, while the other cities in England also furnish advantageous markets for geese. Sarthe geese have the highest reputation in London, the giant birds of Toulouse finding less favor. Geese should not exceed 9 to 12 pounds each in weight, and the tendency to produce Sarthe geese in excess of this size is discouraged. Southern Hungary has in recent years produced fine birds to compete when dressed with the French geese in London, but there is a reddening of the skin and a sensible depreciation in quality, due to the length of the transport. Russia has made some attempts, but produces only a mongrel, which fattens with difficulty.

Great Britain imported 10,000,000 great hundreds (1,920,000,000) of eggs in 1899. Many Russian eggs are credited to Germany, though originally coming from Russia, and many coming from Italy are credited to France and Belgium. French eggs would seem especially fitted for prompt consumption, on account of the short transport; but, unfortunately for the French producers, an unwise practice has been adopted by many farmers, especially in Normandy, of keeping eggs many days or even weeks in the hope of getting better prices, and as a result the eggs have not reached London in perfect condition, and French eggs have become discredited, and one large firm is quoted as spending not more than £30 a week where formerly £1,000 a week was spent, and this discrediting of French eggs has happened at a time when other countries are perfecting their methods.

Denmark, exporting four times as much butter to England as France does, has applied to the egg trade those principles of cooperation which have already proved successful in the butter trade and other industries connected with agriculture. In the rural districts of the little Baltic kingdom, cooperative societies undertake the exportation of fresh eggs of a good quality, and members are required to scrupulously conform with the rules of the society. To ascertain for example, by what member of the society a bad egg has been furnished, the shell of every egg is required to be marked with an India rubber stamp, so that the person by whom the egg was supplied may be at once identified. Depots are established along the lines of the railway, and each producer is required to make a delivery of eggs at least three times a week. At each depot, there is an agent of the society who has the right to refuse any eggs about which suspicion arises or which are more than four days old. The approved eggs are sorted according to size. The inspection takes place with a lamp in a darkened chamber, and the discovery of a single rotten egg in London would be followed by a heavy claim against the Danish depot which furnished it. The Danish egg trade in England is growing tremendously, the English consumers appreciating their carefulness; and the Italians are imitating the Danish system, two centers of export having already been established on Danish principles. French producers are urged by M. de Loverdo to adopt the same system.

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The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

CONCENTRATED PERFUMES.

THERE has appeared quite recently in the perfumery market an entirely new line of perfumes put up in a solid state and having a very intense odor.

The perfumes of flowers, as is well known, may be extracted by several different methods. The simplest of these is distillation—a process easy of application, and one that furnishes good results with bodies that are not altered by a high temperature. If it be desired to avoid such alteration, enfleurage is employed. This

Frejus, a large extractor which appears to solve in a rational and simple manner the problem of drawing the perfume from flowers.

This apparatus consists essentially of three receptacles, *A*, *B*, *C*, with which are respectively connected the refrigeratory worms, *S*¹, *S*², *S*³, placed in the interior of a vat, *D*.

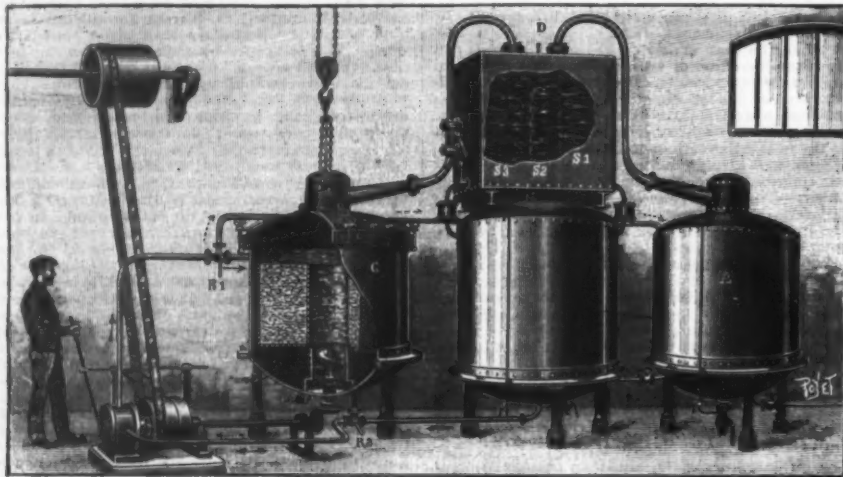
The three receptacles are connected through the intermedium of a pump and pipes properly arranged.

The receptacle, *B*, receives the liquid designed for drawing the perfume from the flowers, which are

the solvent is led back to *B* to be used again. In order to prevent any loss during the distillation, which may be watched through two small windows placed on the right and left of the vat, *D*, communication between the reservoir, *B*, and the atmosphere is established by a worm, *S*³.

The crude product of the exhaustion is concentrated in a water-bath, purified carefully by appropriate methods, and then placed in handsome porcelain jars.

At an early hour of the day, after warm weather sets in, long lines of vehicles filled with fragrant flowers, from which the perfume is to be extracted, are seen wending their way toward the works. And what will remain of the millions of petals under the weight of which the wagons groan? Not much; merely a few ounces of waxy substances which perfumers will buy at the price of gold. Such substances possess so odoriferous a power that one pound of concrete oil advantageously replaces one hundred pounds of pomade obtained through enfleurage. For the foregoing particulars and the illustration we are indebted to *La Nature*.



ARRANGEMENT OF EXTRACTORS EMPLOYED BY THE SOCIÉTÉ DES PARFUMS DU LITTORAL AT FREJUS.

consists in placing in contact with oil or vaseline the odoriferous parts of the flowers. The process is, unfortunately, difficult of application for practical purposes, and requires the use of cumbersome and costly apparatus.

Upon large plates of glass, three feet square, and set into wooden frames is spread a thin layer of grease, and upon this are strewn the petals of the flowers. When all the perfume has been extracted, the frames are recharged with fresh petals. The operation is repeated several times in succession, until the grease is saturated. This latter is then collected with care and preserved in a cool place until it is desired to use it for the preparation of alcoholic extracts.

It is not rare to find as many as 10,000 frames in the establishments that utilize this process. An endeavor has, therefore, been made for a long time to substitute for fatty matters solvents which can be more conveniently managed, and which requires the use of less expensive apparatus.

Robiquet, in 1835, was the first to conceive the idea of using ether. Milon and Ferrand in 1856, Wild in 1860, Egrot in 1863, and Hirzle in 1864, made percepti-

placed in a wire gauze basket arranged in the receptacle, *C*. A screw mounted below this basket, the center of which is made hollow, causes a constant circulation of the dissolving liquid in which the flowers are immersed. The basket is refilled at intervals by momentarily raising the cover of the receptacle by means of the pulley suspended above it.

The receptacle, *B*, having been previously filled with the proper solvent (carbon disulfide, acetone, or petroleum ether), the valves of the three-way cocks, *R*¹, *R*², *R*³, are properly set to cause the liquid from the receptacle, *B*, to pass into the receptacle, *C*, when the pump is started. The course followed by the liquid is indicated by the unbroken arrows. As soon as *C* is filled, the cocks, *R*¹, *R*², are closed, and the belt is shifted from the pump pulley to that on the shaft which controls the screw, thus setting the latter in motion. The exhaustion of the flowers then begins.

When this first operation is finished, the receptacles, *C* and *A*, are put in communication through the cocks, *R*⁴, *R*⁵, and the liquid derived from the exhaustion is forced in the direction shown by the dotted arrows.

Having entered the receptacle, *A*, the solvent is ex-

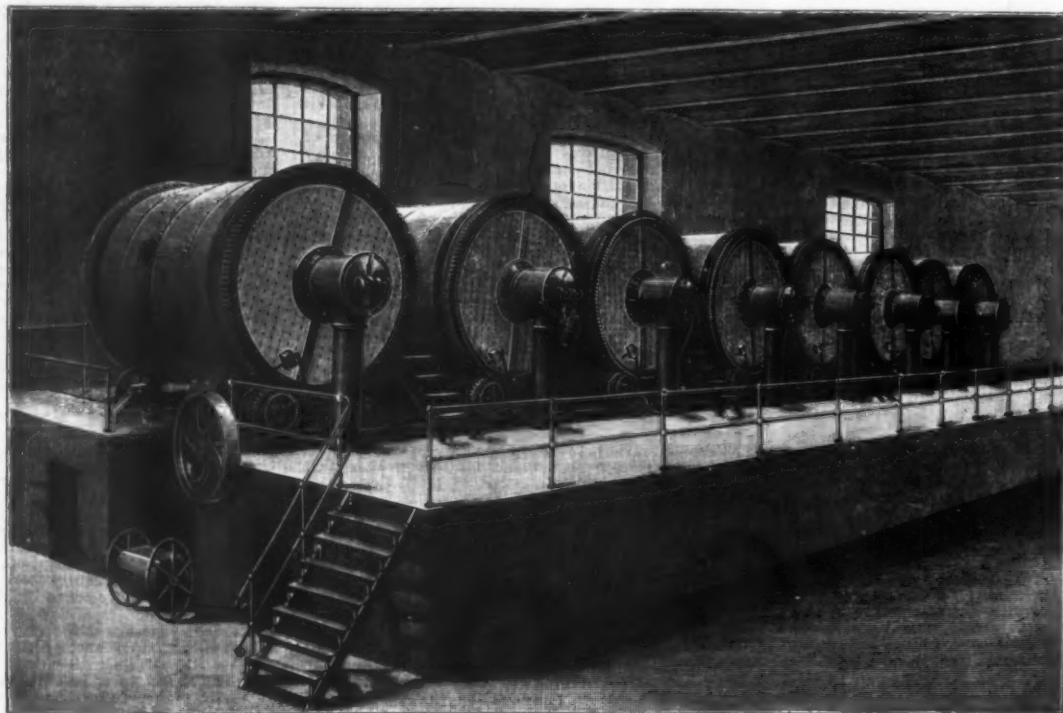
PNEUMATIC MALTING.

If a grain of barley be placed in moist earth, or upon moistened sand or paper, it will begin to absorb water and swell. Soon there will appear at one of its ends a rapidly-growing white spot which sprouts; at the other end little roots break forth. Simultaneously the diastase, the fermenting material of the barley begins to convert the small amount of starch into sugar. The diastase then increases in quantity; and to bring about this increase is the purpose of the process of malting.

All kinds of grain can be used in making malt; but barley is best adapted to the purpose. Before treatment the grain is carefully cleaned. It is then steeped in cold water, whereby the good seeds can be told from the bad. Dead seeds float; good seeds sink. After the grain has been steeped for a period which in summer varies from 36 to 48 hours and in winter from 3 to 5 days, the water is drawn off; and the grain transferred to the germinating-room. The temperature during germination is never allowed to fall below 59° F., or rise above 65° F. At low temperatures germination proceeds too slowly; at high temperatures, very much more rapidly, but with too great a production of carbon dioxide gas. At moderate temperatures the greatest amount of diastase is obtained. During germination the temperature rises; the grain begins to "sweat," and much carbon dioxide is given off. In order to prevent the grain from becoming overheated, the piles are turned over and over. As soon as the roots have sprouted to one and one-half times the length of a grain, germination is stopped; for it has been found that at this period the maximum amount of diastase has been produced.

The turning over of the malt by hand is not only tedious but also laborious. Malters naturally cast about them for some mechanical device which would perform the work of turning over the germinated grain. Most of them have adopted the "pneumatic" malting-machine, which although primarily intended for the use of brewers, has been found admirably adapted for their purpose.

The steeped, swollen grain is transferred to great iron drums, slowly rotating on their axes. Air is drawn through the drums to remove the moisture and carbon dioxide gas.



PNEUMATIC MALTING DRUMS.

ble improvements upon the Robiquet method. In 1879, M. L. Naudin made known his ingenious exhaustion apparatus. Later on, M. Massignon devised an extractor that was utilized for quite a long time at Cannes. But all the apparatus employed up to the present have been difficult to manage and not very certain. The losses of solvents have been large and the yield of perfumes not very satisfactory.

We have, says *La Nature*, recently seen in operation in the works of Société des Parfums du Littoral, at

pelled by a current of steam and enters the reservoir, *B*, in a state of absolute purity, ready to be used for a second operation. The products of exhaustion remain in the receptacle, *A*, whence they are easily removed. Upon the operation being several times repeated, the odoriferous substance contained in the flowers is completely extracted. At the end of the final operation, the material treated is heated by means of a worm in which steam circulates, so as to expel completely the liquid with which it is impregnated. Nothing is lost; and

The grain, when completely malted, is called "green malt." Green malt, if it cannot be used immediately, after having been made, is deprived of its water and converted into "air-dried" or "kiln-dried malt." To produce air-dried malt, green malt is spread over burdles and dried at ordinary temperatures in summer and in heated rooms during winter. In making kiln-dried malt the green-malt is heated to a temperature of 112° F. The heating is intended to dry and not to roast; for which reason the temperature is not allowed

to rise much above 113°. After having been desiccated, the rootlets, technically known as "coombs," are stamped from the malt and separated by screening drums.—Der Stein der Weisen.

LIGNITE.

PROBABLY the time will come when our grandchildren and great-grandchildren will look down upon us with a certain scorn as having lived in the age when steam was generated from dust, soot and smoke, for

form distance from the ground? The question seems to be a difficult one to answer.

The trees to which these stumps belong were taxodiu, a species of swamp cypress which is now extinct, but which doubtless played the same rôle in those times as the taxodium of the present day plays in the morasses of Virginia, where it attains a height of 130 feet and a circumference equal to that given above. Between and under these trees, which stood several yards deep in water, grew a forest of reeds, grass and small shrubs, and each year these increased in number



FIG. 1.—SURFACE LIGNITE MINE.

they will learn to gain from water, in the form of electricity, not only the power needed for industrial purposes, but also all light and heat. A supply amounting to about one hundred thousand millions of horse power, slumbers in the waters of Germany alone, more, much more than will ever be used even by our exacting descendants, who will, in a certain way occupy the same position as our great grandfathers, for they will have returned to the original source of power, water. But what a difference between those former times and the ages to come. A period covering a development as wonderful, from an intellectual point of view, as that which covered the evolution from the ape to man.

We, unfortunately, do not live in the time that is to come, but in the age of steam, for the little electricity which we now enjoy is developed principally by steam; we are entirely dependent, both in the little world of the home and in the larger one of industry, on coal—black diamonds as it is called—and just as dependent on the millions of hands that bring these diamonds to the light of day. The strikes of miners bring us to a realizing sense of this condition of things, for entire industries have been wiped out, particularly in Austria, is this the case, and many times the passenger and freight traffic of railroads is much affected by them. Entire cities have been left in darkness, and the poorer inhabitants have had to go without fuel of any kind which could be obtained only by paying exorbitant prices. The results of a local strike which was limited almost entirely to lignite mines show us plainly that all industry would be very materially crippled if miners of the other kinds of coal as well as those of the lignite should suddenly stop work for a considerable length of time.

Of course, lignite or brown coal is of much less importance to the world at large than the hard or stone coal; to convey some idea of the comparative value of these different kinds of coal we will give the following statistics. In Prussia, in 1898, 90,000,000 tons of hard coal were purchased at a value of about \$152,798,000, and 26,000,000 tons of lignite at a value of something over \$14,042,000. It is well known that the brown coal does not give such an intense heat as the stone coal, but it gives a more uniform heat and is, therefore, considered necessary for industries of a certain class and, in fact, absolutely indispensable for large districts located at a long distance from stone coal mines. Brown coal is of much more recent origin than hard coal. Its name, which may be traced to its appearance, does not always describe it perfectly, for some lignite is as black as hard coal, while on the other hand some stone coal looks much like lignite. There are several different kinds of brown coal that are specially valuable because of the ease with which briquets can be made of them. Paraffin, petroleum, benzine, etc., are made from certain kinds of brown coal. All lignite shows plainly its vegetable origin, often retaining the structure of the wood. It belongs to the tertiary period, when swamps, moors, inland lakes, bays, the deltas of rivers and similar localities were the places where there was an accumulation of vegetation, which, under the favorable conditions of temperature that then existed, was developed to gigantic size. Trees with a diameter of 6 feet and a circumference of 30 feet were no rarity. The stumps of such prehistoric giants (as shown in Fig. 1.) may still be seen in the excavations of the mines at Sentenber, not far from Berlin.

As is well known, there are two theories in regard to the formation of the beds of brown coal, as well as those of true coal. According to one of these theories they were formed chiefly from masses of vegetable matter which were deposited by streams of water; and according to the other beds were formed by the falling of parts of plants on the spot where they grew. There may be good foundation for the former theory, but where such upright stumps are found, as are shown in our engraving, it is safe to affirm that the latter theory is correct. These trees must have grown where their stumps are still firmly rooted—their roots can be traced for many yards; but what power, one naturally asks, has cut down these giants or broken them off at a uni-

and, with the leaves and branches which fell from the trees to the water, formed a deposit which sank, forming a rich black mold, which was gradually changed into coal. Later the trees and old trunks that projected above the water rotted at its surface and were also fell into the mass of vegetable matter and were covered by the water which thus did its part by bringing all to one level. This accounts for the uniform height of the stumps shown in our engraving. This stage of the development of coal deposits is presented by the so-called Dismal or Alligator Swamps of the present time which extend along the coast of the Atlantic Ocean from Virginia to North Carolina covering thousand of square miles.

The depth of the stratum of earth that covers such deposits depends upon the natural development of the crust of the earth or upon convulsions of the earth; in this way we have some mines far underground, as shown in Fig. 2, and some near the surface, as shown in Fig. 1. The quality of the coal is much affected by the depth of the stratum of earth and the pressure which it exerts upon the bed of coal. Miners do not like to come upon the trunks and stumps of trees, which are so interesting to naturalists, for it is difficult to remove them, and the labor does not pay well; they must be carefully separated from the coal that is in-



FIG. 2.—UNDERGROUND LIGNITE MINE.

tended for making briquets and they are of little value for anything else.

The length of time required for the formation of beds of coal varies considerably, but one would not be much out of the way in estimating it at ten thousand years.—Zur Guten Stunde.

The women of Colorado are actively engaged in trying to obtain possession of the cliff and cave dwellings in the southwestern part of the state.

THE SPLÜGEN TUNNEL.

THE demand for increased railway communication between Switzerland and Italy seems to warrant the development of improved routes, and no sooner is one enterprise for piercing the Alps fairly started than another is agitated. The Mont Cenis was followed by the St. Gothard and the Aarberg, while the Simplon is now being actively pushed, and this will probably be followed by a tunnel at the Splügen Pass, the preliminary schemes for which are given in a recent issue of the Schweizerische Bauzeitung.

The idea of a connection between Eastern Switzerland and Italy is not new, having been discussed as long ago as 1886, when preliminary surveys were made under the joint auspices of the Splügenkomitee on behalf of Switzerland, and the Società Adriatica on the part of Italy. The plans included a railway from Chur, in Switzerland, to Chiavenna, in Italy, to which points railway existed, the length of new railway thus required being about 61 miles.

The estimated cost of the road, according to the plans of the Italian engineers, was 146,600,000 francs, and the magnitude of the amount led to a postponement of the scheme until a further inspection of the various possible routes might make it clear that the most economical plan had been chosen. The matter was, therefore, referred to the well-known Swiss engineer, Herr R. Moser, by whom the article referred to was written, the object being to select a route which should conform to the following conditions:

1. The highest elevation of the road must not be more than 1,200 meters above the sea.

2. The maximum grade on any open part of the road must not exceed 2.6 per cent., and in tunnels of more than 600 meters in length it must not exceed 2.8 per cent.

3. No curves may be of less than 300 meters radius.

4. The grades in the main tunnel must not exceed 0.6 per cent.

5. The road is to be planned for single track, except for the proportion between the stations nearest the tunnel and the tunnel portals, and in the tunnel itself, where the road is to be double track.

6. The line of the road in the Bergell valley is to lie as near to the Swiss frontier as possible.

Herr Moser proceeds to examine the Italian route, giving plans and profiles, and shows that by a modification the cost may be materially reduced. Both plans involve the construction of a main tunnel, 18,640 meters (11.57 miles) long in the Italian plan, and 18,180 meters (11.29 miles) in the Moser plan. In the approaches, however, Herr Moser has succeeded in modifying the plans so as to permit of a material reduction in the estimated cost, and in the topographical maps accompanying this paper he shows the comparative routes of the two schemes very clearly. From these it appears that the new plan for the Splügen railway and tunnel offer no difficulties greater than those successfully overcome in the St. Gothard railway, the cost of the tunnel being somewhat greater only because of the greater length.

Herr Moser's estimate for the cost of the revised route is a total of 112,554,000 francs, a saving of more than 34,000,000 francs over the Italian route, this gain being accomplished by shortening the length of the railway by about 5 kilometers, and by reducing very materially the lengths of the shorter tunnels in the approaches.

Since the proposed Splügen route would form a portion of the same system as the Brenner and the St. Gothard routes, it is desirable to show to what extent it could expect to share the traffic. Taking Zurich

and Bale as the commercial terminals in Switzerland, and Milan in Italy, it appears that there is but little difference so far as distances go, but that there is a very material advantage in favor of the Splügen route as regards grades and elevation to be overcome, this latter amounting to more than 800 meters in favor of Splügen.

The volume of traffic to be looked for by the opening of this proposed railway cannot be deduced from Swiss sources, since the greater part of it would have to come from other countries, Switzerland profiting

thus by its position as the most available highway. Whether the possible returns to be expected from this business would be sufficient to make the construction of a work of such magnitude profitable remains to be seen, but it is not improbable that before the Simpson Tunnel is wholly completed, its successor at the Spliton Pass will have been commenced.—Engineering Magazine.

LIQUID HYDROGEN.*

From the year 1878, when the experiments of Cailletet and Pictet were attracting the attention of the scientific world, it became a common habit in text books to speak of all the permanent gases, without any qualification, as having been liquefied, whereas these experimentalists, by the production of an instantaneous mist in a glass tube of small bore, or a transitory liquid jet in a gas expanding under high compression into air, had only adduced evidence that sooner or later the static liquid form of all the known gases would be attained. Neither Pictet nor Cailletet in their experiments ever succeeded in collecting any of the permanent gases in that liquid form for scientific examination. Yet we meet continually in scientific literature with expressions which lead one to believe that they did. For instance, the following extract from the "Proceedings" of the Royal Society, 1878, illustrates this point very well: "This award (Davy Medal) is made to these distinguished men (Cailletet and Pictet) for having independently and contemporaneously liquefied the whole of the gases hitherto called permanent." Many other quotations of the same kind may be made. As a matter of fact six years elapsed, during which active investigation in this department was being prosecuted, before Wroblewski and Olszewski succeeded in obtaining oxygen as a static liquid, and to collect liquid hydrogen, which is a much more difficult problem, has taken just twenty years from the date of the Pictet and Cailletet experiments.

Wroblewski made the first conclusive experiment on the liquefaction of hydrogen in January, 1884. He found that the gas cooled in a capillary glass tube to the boiling point of oxygen, and expanded quickly from 100 to 1 atmosphere, showed the same appearance of sudden ebullition lasting for a fraction of a second, as Cailletet had seen in his early oxygen experiments. No sooner had the announcement been made, than Olszewski confirmed the result by expanding hydrogen from 100 atmospheres, previously cooled to the temperature given by liquid oxygen and nitrogen evaporating under diminished pressure. Olszewski, however, declared in 1884 that he saw colorless drops, and by partial expansion to 40 atmospheres, the liquid hydrogen was seen by him running down the tube. Wroblewski could not confirm Olszewski's results, his hydrogen being always obtained in the form of what he called a "liquide dynamique," or the appearance of an instantaneous froth. Olszewski himself seven years later repeated his experiments of 1884 on a larger scale, confirming Wroblewski's results, thereby proving that the so-called liquid hydrogen of the earlier experiments must have been due to some impurity. The following extract from Wroblewski's paper states very clearly the results of his work on hydrogen:

"L'hydrogène soumis à la pression de 180 atm. jusqu'à 190 atm., refroidi par l'azote bouillant dans la vide (à la température de sa solidification) et détendu brusquement sous la pression atmosphérique présente une mousse bien visible. De la couleur grise de cette mousse, on ne peut distinguer de gouttelettes incolores, on ne peut pas encore deviner quelle apparence aurait l'hydrogène à l'état de liquide statique et l'on est encore moins autorisé à préciser s'il a ou non une apparence métallique. J'ai pu placer dans cette mousse ma pile thermo-électrique, et j'ai obtenu suivant les pressions employées des températures de -208° jusqu'à -211° C. Je ne puis pas encore dire dans quelle relation se trouvent ces nombres avec la température réelle de la mousse ou avec la température d'ébullition de l'hydrogène sous la pression atmosphérique, puisque je n'ai pas encore la certitude que la faible durée de ce phénomène ait permis à la pile de se refroidir complètement. Néanmoins, je crois aujourd'hui de mon devoir de publier ces résultats, afin de préciser l'état actuel de la question de la liquefaction de l'hydrogène."[†]

It is well to note that the lowest thermo-electric temperature recorded by Wroblewski during the adiabatic expansion of the hydrogen (namely, -211°) is really equivalent to a much lower temperature on the gas-thermometer scale. The most probable value is -230°, and this must be regarded as the highest temperature of the liquid state, or the critical point of hydrogen, according to his observations. In a posthumous paper of Wroblewski's on "The Compression of Hydrogen," published in 1890, an account appears of further attempts which he had made to liquefy hydrogen. The gas compressed to 110 atmospheres, was cooled by means of liquid nitrogen under exhaustion to -213°. By suddenly reducing the pressure, as low a temperature as -233° on his scale was recorded, but without any signs of liquefaction. This expansion gives a theoretical temperature of about 15° absolute in the gas particles. The above methods having failed to produce static hydrogen, Wroblewski suggested that the result might be attained by the use of hydrogen gas as a cooling agent. From this time, until his death in the year 1888, Wroblewski devoted his time to a laborious research on the isothermals of hydrogen at low temperatures. The data thus arrived at enabled him, by the use of Van der Waal's formulae, to calculate the critical constants, and also the boiling point of liquid hydrogen.

Olszewski returned to the subject in 1891, repeating and correcting his old experiments of 1884, which Wroblewski had failed to confirm, using now a glass tube 7 mm. in diameter instead of one of 2 mm. as in the early trials. He says: "On repeating my former experiments, I had no hope of obtaining a lower temperature by means of any cooling agent, but I hoped that the expansion of hydrogen would be more efficacious, on account of the larger scale on which the experiments were made." The results of these experiments Olszewski describes as follows: "The phenomenon of hydrogen ebullition, which was then observed, was

much more marked and much longer than during my former investigations in the same direction. But even then I could not perceive any meniscus of liquid hydrogen." Further, "The reason for which it has not hitherto been possible to liquefy hydrogen in a static state, is that there exists no gas having a density between those of hydrogen and of nitrogen, and which might be for instance 7-10 (H = 1). Such a gas could be liquefied by means of liquid oxygen or air as cooling agent, and be afterwards used as a 'refrigerant' in the liquefaction of hydrogen."

Professor Olszewski, in 1895, determined the temperature reached in the momentary adiabatic expansion of hydrogen at low temperatures, just as Wroblewski had done in 1885, only he employed a platinum-resistance thermometer instead of a thermo-junction. For this purpose he used a small steel bottle of 20 or 30 c.c. capacity, containing a platinum-resistance thermometer; in this way the temperatures registered were regarded as those of the critical and boiling points of liquid hydrogen, a substance which could not be seen under the circumstances and was only assumed to exist for a second or two during the expansion of the gaseous hydrogen in the small steel bottle.

The results arrived at by Wroblewski and Olszewski are giving in the following table, and it will be shown later on that Wroblewski's constants are nearest the truth.

	Wroblewski, 1885.	Olszewski, 1895.
Critical temperature	-240°	-234°
Boiling point	-254°	-243°
Critical pressure	13 atm.	20 atm.

The accuracy of Wroblewski's deductions regarding the chief constants of liquid hydrogen following from a study of the isothermals of the gas is a signal triumph for the theory of Van der Waals and a monument to the genius of the Cracow physicist. From these results we may safely infer that supposing a gas is hereafter discovered in small quantity four times more volatile than liquid hydrogen, having a boiling point of about 5° absolute, and, therefore, incapable of direct liquefaction by the use of liquid hydrogen, yet by a study of its isothermals we shall succeed in finding out its most important liquid constants, although the isolation of the real liquid may for the time be impossible.

In a paper published in The Philosophical Magazine, September, 1884, "On the Liquefaction of Oxygen and the Critical Volumes of Fluids," the suggestion was made that the critical pressure of hydrogen was wrong and that instead of being 99 atmospheres (as deduced by Sarrau from Amagat's isothermals) the gas had probably an abnormally low value for this constant. This view was substantially confirmed by Wroblewski finding the critical pressure of 3.3 atmospheres, or about one-fourth of that of oxygen. The Chemical News, September 7, 1894, contains an account of the stage the author's hydrogen experiments had reached at that date. The object was to collect liquid hydrogen at its boiling point, in an open vacuum vessel, which is a much more difficult problem than seeing it in a glass tube under pressure and at a higher temperature. In order to raise the critical point of hydrogen to about -210°, from 2 to 5 per cent. of nitrogen or air was mixed with it. This is simply making an artificial gas containing a large proportion of hydrogen which is capable of liquefaction by the use of liquid air. The results are summed up in the following extract from the paper: "One thing can, however, be proved by the use of the gaseous mixture of hydrogen and nitrogen, namely that by subjecting it to a high compression at a temperature of -200° and expanding the resulting liquid into air, a much lower temperature than anything that has been recorded up to the present time can be reached. This is proved by the fact that such a mixed gas gives, under the conditions, a paste or jelly of solid nitrogen, evidently giving off hydrogen, because the gas coming off burns fiercely. Even when hydrogen containing only some 2 to 5 per cent. of air is similarly treated, the result is a white solid matter (solid air) along with a clear liquid of low density, which is so exceedingly volatile that no known device for collecting it has been successful." This was in all probability the first liquid hydrogen obtained, and the method is applicable to other difficultly liquefiable gases.

Continuing the investigations during the winter of 1894, and the greater part of 1895, the author read a paper before the Chemical Society in December of that year entitled, "The Liquefaction of Air and Research at Low Temperatures,"[‡] in which occasion was taken to describe for the first time the mode of production and use of a liquid hydrogen jet. At the same meeting Prof. William Ramsay made an announcement of a sensational character, which amounted to stating that my hydrogen results had been not only anticipated but bettered. The statement made to the society by Prof. Ramsay, reads as follows: "Prof. Olszewski had succeeded in liquefying hydrogen, and from unpublished information received from Cracow, he (Ramsay) was able to state that a fair amount of liquid had been obtained, not as a froth, but in a state of quiet ebullition, by surrounding a tube containing compressed hydrogen by another tube also containing compressed hydrogen at the temperature of oxygen boiling at a very low pressure. On allowing the hydrogen in the middle jacket suddenly to expand, the hydrogen in the innermost tube liquefied, and was seen to have a meniscus. Its critical point and its boiling point, under atmospheric pressure, were determined by means of a resistance thermometer."[§]

This announcement of Prof. Ramsay's had from its very specific and detailed experimental character the merit of the appearance of being genuine, although it was never substantiated, either by the production of the Cracow document, or by any subsequent publication of such important results by Prof. Olszewski himself. My observation at the time on Prof. Ramsay's communication was that quotations had been made in my paper from the most recent publications of Prof. Olszewski in which he made no mention of getting "Static Hydrogen" or of seeing a meniscus" or of getting what Prof. Ramsay alleged "a fair amount of liquid, not as a froth, but in state of quiet ebullition." To achieve such a result would require a very different scale of experiment from anything Prof. Olszewski had so far described.

Naturally an early corroboration of the startling statement made by Prof. Ramsay as to this alleged anticipation was expected, but strange to say Prof. Olszewski published no confirmations of the experiments detailed by Prof. Ramsay in scientific journals of date immediately preceding my paper or during the following years, 1896, 1897, or up to May, 1898.

The moment the announcement was made by me to the Royal Society in May, 1898, that, after years of labor, hydrogen had at last been obtained as a static liquid, Prof. Ramsay repeated the story to the Royal Society that Olszewski had anticipated my results (basing the assertion solely on the contents of the old letter received some two and a half years before), in spite of the fact that during the interval he, Prof. Ramsay, must have known that Prof. Olszewski had never corroborated in any publication either the form of the experiments he had so minutely described or the results which were said to follow. Challenged by me at the Royal Society meeting on May 12, 1898, to produce Olszewski's letter of 1895, he did not do so, but at the next meeting of the society, Prof. Ramsay read a letter he had received during the interval from Prof. Olszewski, denying that he had ever stated that he had succeeded in producing static liquid hydrogen. This oral communication of the contents of the new Olszewski letter (of which it is to be regretted there is no record in the published proceedings of the Royal Society) is the only kind of retraction Prof. Ramsay has thought fit to make of his published misstatements of facts. No satisfactory explanation has yet been given by Prof. Ramsay of his twice repeated categorical statements made before scientific bodies of the results of experiments which, in fact, had never been made by their alleged author. The publicity that has been given to this controversy makes it imperative that the matter should not be passed over, but once for all recorded.

The report of a Friday Evening Discourse on "New Researches on Liquid Air,"[¶] contains a drawing of the apparatus employed for the production of a jet of hydrogen containing visible liquid. This is reproduced in Fig. 1. A represents one of the hydrogen cylinders; B and C vacuum vessels containing carboric acid under exhaustion and liquid air respectively; D is the coil; E the pin-hole nozzle; and F the valve. By means of this hydrogen jet, liquid air can be quickly transformed into a hard solid. It was shown that such a jet could be used to cool bodies below the temperature that it is possible to reach by the use of liquid air, but all attempts to collect the liquid hydrogen from the jet

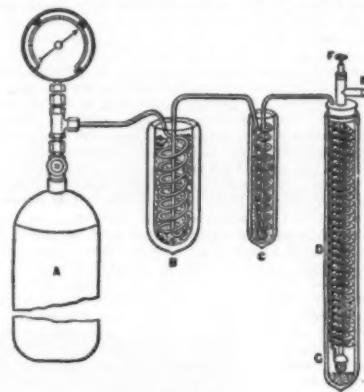


FIG. 1.

in vacuum vessels failed. No other investigator improved on my results,[†] or has indeed touched the subject during the last three years. The type of apparatus used in these experiments worked well, so it was resolved to construct a much larger liquid-air plant, and to combine with it circuits and arrangements for the liquefaction of hydrogen. This apparatus took a year to build, and many months have been occupied in the testing and preliminary trials. The many failures and defects need not be detailed.

On May 10, 1898, starting with hydrogen cooled to -205°, and under a pressure of 180 atmospheres, escaping continuously from the nozzle of a coil of pipe at the rate of about 10 to 15 cubic feet per minute, in a vacuum vessel doubly silvered and of special construction, all surrounded with a space kept below -200°, liquid hydrogen commenced to drop from this vacuum vessel into another doubly isolated by being surrounded with a third vacuum vessel. In about five minutes, 20 c.c. of liquid hydrogen were collected, when the hydrogen jet froze up, from the accumulation of air in the pipes frozen out from the impure hydrogen. The yield of liquid was about one per cent. of the gas. The hydrogen in the liquid condition is clear and colorless, showing no absorption spectrum, and the meniscus is as well defined as in the case of liquid air. The liquid must have a relatively high refractive index and dispersion, and the density appears at first sight to be in excess of the theoretical density, namely 0.18 to 0.13, which we deduce respectively from the atomic volume of organic compounds, and the limiting density found by Amagat for hydrogen gas under infinite compression. A preliminary attempt, however, to weigh a small glass bulb in the liquid made the density only about 0.08, or half the theoretical. My old experiments on the density of hydrogen in palladium gave a value for the combined element of 0.62. Not having arrangements at hand to determine the boiling point other than a thermo-junction which gave entirely fallacious results, experiments were made to prove the excessively low temperature of the boiling fluid. In the first place if a long piece of glass tubing, sealed at one end and open to the air at the other, is cooled by immersing the closed end in the liquid hydrogen, the tube immediately fills where it is cooled with solid air. A small glass tube filled with liquid oxygen when cooled in liquid hydrogen is transformed into a bluish white solid. This is a proof that the

* Lecture before the Royal Institution of Great Britain. From Science.

† Compt. Rend., 1886, 100, 961.

‡ Proceedings of the Chemical Society, No. 158, 1895.

§ "Proceedings" of the Chemical Society, No. 194, 1897-1898.

¶ Proceedings of the Royal Institution, 1896.

† Proceedings of the Chemical Society, No. 158, 1895.

boiling point of hydrogen is much lower than any temperature previously reached by the use of liquid nitrogen evaporating in vacuo, seeing oxygen always remains liquid under such conditions. A first trial of putting liquid hydrogen under exhaustion gave no appearance of transition into the solid state. When the vacuum tube containing liquid hydrogen is immersed in liquid air so that the external wall of the vacuum vessel is maintained at about -190° , the hydrogen is found to evaporate at a rate not far removed from that of liquid air from a similar vacuum vessel under the ordinary conditions of temperature. This leads me to the conclusion that, with proper isolation, it will be possible to manipulate liquid hydrogen as easily as liquid air.

The boiling point of liquid hydrogen at atmospheric pressure in the first instance was determined by a platinum resistance thermometer. This was constructed of pure metal and had a resistance of 53 ohms at 0° C., which fell to about 0.1 ohm when the thermometer was immersed in liquid hydrogen. The reduction of this resistance to normal air thermometer degrees gave the boiling points -238.2° and -238.9° respectively by two extrapolation methods, and -237° by a Dickson formula.* The boiling point of the liquid seems, therefore, to be -238° C. or 35° absolute, and is thus about 5° higher than that obtained by Olzewski by the adiabatic expansion of the compressed gas, and about 8° higher than that deduced by Wroblewski from Van der Waal's equation. From these results it may be inferred that the critical point of hydrogen is about 50° absolute, and that the critical pressure will probably not exceed 15 atmospheres.

If we assume the resistance reduced to zero, then the temperature registered by the electric thermometer ought to be -244° C. At the boiling point of hydrogen, registered by the electric resistance thermometer, if the law correlating resistance and temperature can be pressed to its limits, a lowering of the boiling point of hydrogen by 5° or 6° C., would, therefore, produce a condition of affairs in which the platinum would have no resistance, or would become a perfect conductor. Now we have every reason to believe that hydrogen, like other liquids will boil at a lower temperature the lower the pressure under which it is volatilized. The question arises, how much lowering of the temperature can we practically anticipate? For this purpose we have the boiling point given by the hydrogen gas thermometer, and critical data available, from which we can calculate an approximate vapor pressure formula, accepting 23° absolute as about the boiling point, 33° absolute as the critical temperature, and 15.4 atmospheres as the critical pressure; then, as a first approximation—

$$\log p = 6.410 - \frac{77.62}{T} \text{ mm.} \quad (1)$$

If, instead of using the critical pressure in the calculation, we assume the molecular latent heat of hydrogen to be proportional to the absolute boiling point, then, from a comparison with an expression of the same kind, which gives accurate results for oxygen tensions below one atmosphere, we can derive another expression for hydrogen vapor pressures, which ought to be applicable to boiling points under reduced pressure. The resulting formula is—

$$\log p = 7.0808 - \frac{88}{T} \text{ mm.} \quad (2)$$

Now formula (1) gives a boiling point of 14.2° absolute under a pressure of 25 mm., whereas the second equation (2) gives for the same pressure 15.4° absolute. As the absolute boiling point under atmospheric pressure is about 23° , both expressions lead to the conclusion that ebullition under 25 mm. pressure ought to reduce the boiling point some 7° C. For some time experiments have been in progress with the object of determining the temperature of hydrogen boiling under about 25 mm. pressure, by the use of the platinum thermometer; but the difficulties encountered have been great, and repeated failures very exasperating. The troubles arise from the conduction of heat by the leads; the small latent heat of hydrogen, volume for volume, as compared with liquid air; the inefficiency of heat isolation; and the strain on the thermometer, brought about by solid air freezing on it and distorting the coil of wire. In many experiments, the result has been that all the liquid hydrogen has evaporated before the pressure was reduced to 25 mm., or the thermometer was left imperfectly covered. The apparatus employed will be understood from Fig. 3. The liquid hydrogen collected in the vacuum vessel, A, was suspended in a larger vessel of the same kind, B, which is so constructed that a spiral tube joins the inner and outer test-tubes of which B is made, thereby making an opening into the interior at C. The resistance thermometer, D, and leads, E, pass through a rubber cork, F, and the exhaustion takes place through G. In this way the cold vapors are drawn over the outside of the hydrogen vacuum vessel, and this helps to isolate the liquid from the convective currents of gas. To effect proper isolation, the whole apparatus ought to be immersed in liquid air under exhaustion. Arrangements of this kind add to the complication, so in the first instance the liquid was used as described. The liquid hydrogen evaporated quietly and steadily under a diminished pressure of about 25 mm. Naturally the liquid does not last long, so the resistance has to be taken quickly. Just before the reduction of pressure began, the resistance of the thermometer was 0.131 ohm. This result compares favorably with the former observation on the boiling point, which gave a resistance of 0.129 ohm. On reducing the pressure, the resistance diminished to 0.114 ohm, and kept steady for some time. The lowest reading of resistance was 0.112 ohm. This value corresponds to -239.1° C., or only one degree lower on its own scale, than the boiling point at atmospheric pressure, whereas the temperature ought to have been reduced at least 5° , under the assumed exhaustion, according to the gas thermometer scale. As a matter of fact, however, this platinum thermometer was, when placed in liquid hydrogen, cooled at starting below its own temperature of perfect conductivity, so that no exhaustion was needed to bring it to this point. The question arises then as to what is the explanation of this result? Has the platinum re-

sistance thermometer arrived at a limiting resistance about the boiling point of hydrogen, so that at a lower temperature its changes in resistance become relatively small—the curve having become practically asymptotic to the axis of temperature? That is the most probable supposition, and it further explains the fact that the temperature of boiling hydrogen obtained by the linear extrapolation of the resistance temperature results in values that are not low enough.

As the molecular latent heats of liquids are proportional to their absolute boiling points, the latent heat of liquid hydrogen will be about two-fifths that of liquid oxygen. It will be shown later, however, that we can reach from 14° to 15° absolute by the evaporation of liquid hydrogen under exhaustion. From analogy, it is probable that the practicable lowering of temperature to be obtained by evaporating liquid hydrogen under pressures of a few mm., cannot amount to more than 10° to 12° C., and it may be said with certainty that, assuming the boiling point 35° absolute to be correct, no means are at present known for approaching nearer than 20° to 25° to the absolute zero of temperature. The true boiling point is in reality about -252° C., in terms of the gas thermometer scale, and the latent heat of liquid is, therefore, about two-ninths that of an equal volume of oxygen, or one-fourth that of liquid nitrogen. The platinum resistance thermometer had a zero point of -263.2 platinum degrees, and when immersed in boiling liquid hydrogen, indicated a temperature of -256.8 on the same scale, or 6.4 platinum degrees from the point at which the metal would theoretically become a perfect conductor. The effect of cooling platinum from the boiling point of liquid oxygen to that of liquid hydrogen is to diminish its resistance to one-eleventh.

The difficulties in liquefying hydrogen caused by the presence of air in the gas have been referred to,* and later experiments had for their object the removal of this fruitful source of trouble. This is by no means an easy task, as quantities amounting to only a fraction of one per cent. accumulate in the solid state, and eventually choke the nozzle of the apparatus, necessitating the abandonment of the operation.

Later experiments enabled me to procure a larger supply of liquid hydrogen with which the determination of certain physical constants has been continued. The first observations made with a pure platinum resistance thermometer had given -238° as the boiling point. A new thermometer, constructed of platinum from a different source, gave practically the same value. As

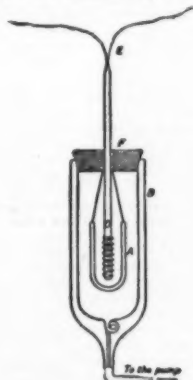


FIG. 2.

these results might be affected by some constant error, the determination was checked by employing a thermometer constructed from an alloy of rhodium and platinum, containing 10 per cent. of the former. Alloys had been shown by Prof. Fleming and the author to differ from pure metals in showing no sign of becoming perfect conductors at the absolute zero of temperature, and a study of the rhodium platinum alloy had shown that the change in conductivity produced by cooling from 0° to the boiling point of liquid air is regular and may be represented by a straight line. As determined by the rhodium platinum thermometer, the boiling point of hydrogen was found to be -246° or some 8° lower than the platinum thermometer gave. Two ways of explaining the discrepancy between the two values suggested themselves. Pure platinum, although its resistance may be represented by a straight line almost down to the solidifying point of air, shows signs of a departure from regularity at about this point, and the curve may become asymptotic at lower temperatures. On the other hand, the resistance of the rhodium platinum alloy diminishes less rapidly at these lower temperatures and is much higher than that of pure platinum under similar conditions. It follows that its resistance curve, in all probability, deviates less from a straight line than is the case with platinum. Either cause would explain the differences observed, but the lower boiling point (-246° or 37° absolute) seemed to be the more probable as it agreed very fairly with the value for the boiling point calculated by the author from Wroblewski's results. As the use of other pure metals or alloys was not likely to lead to more satisfactory results, the problem had to be attacked in a different way, namely, by means of an "air" thermometer containing hydrogen under diminished pressure.

A first attempt has been made at determining the boiling point by a constant volume hydrogen thermometer, working under diminished pressure. This thermometer, which gave the boiling point of oxygen as 90.5° absolute or -182.5° , gave for hydrogen 21° absolute or -252° . The three determinations that have been made are then as follows: (1) pure platinum resistance thermometer, 35° absolute; (2) rhodium platinum resistance thermometer, 27° absolute; (3) hydrogen thermometer, 21° absolute. From this it appears that the boiling point of hydrogen is really lower than was anticipated, and must range between 20° and 22° absolute. Further experiments will be made with thermometers filled with hydrogen prepared from differ-

ent sources. A hydrogen thermometer filled with the gas obtained from the evaporation of the liquid hydrogen itself must be employed.

The approximate density of liquid hydrogen at its boiling point was found by measuring the volume of the gas obtained by evaporating 10 c.c. of the liquid, and is slightly less than 0.07, or about one-sixth that of liquid marsh-gas, which is the liquid known. It is remarkable that, with so low a density, liquid hydrogen is so easily seen, has so well defined a meniscus, and can be so readily collected and manipulated in vacuum vessels. As hydrogen occluded in palladium has a density of 0.63, it follows that it must be associated with the metal in some other state than that of liquefaction.

The atomic volume of liquid hydrogen at its boiling point is about 14.3, the atomic volumes of liquid oxygen and nitrogen being 18.7 and 16.6 respectively at their boiling points. The weight of a liter of hydrogen gas at the boiling point of the liquid is about the same as that of air, at the ordinary temperature. The ratio of the density of the hydrogen gas at the boiling point to that of the liquid is approximately 1:60, as compared with a ratio of 1:255 in the case of oxygen under similar conditions.

The specific heat of hydrogen in the gaseous state and in hydrogenized palladium is 3.4, but may vary probably be 6.4 in the liquid substance. Such a liquid would be unique in its properties; but as the volume of one gramme of liquid hydrogen is about 14 to 15 c.c., the specific heat per unit volume must be nearly 0.5, which is about that of liquid air. It is highly probable, therefore, that the remarkable properties of liquid hydrogen predicted by theory will prove to be less astonishing when they are compared with those of liquid air, volume for volume, at corresponding temperatures.

With hydrogen as a cooling agent we shall get to from 13° to 15° of the zero of absolute temperature, and its use will open up an entirely new field of scientific inquiry. Even so great a man as James Clerk Maxwell had doubts as to the possibility of ever liquefying hydrogen.† He says: "Similar phenomena occur in all the liquefiable gases. In other gases we are able to trace the existence of attractive force at ordinary pressures, though the compression has not yet been carried so far as to show any repulsive force. In hydrogen the repulsive force seems to prevail even at ordinary pressures. This gas has never been liquefied, and it is probable that it never will be liquefied, as the attractive force is so weak." In concluding his lectures on the non-metallic elements delivered at the Royal Institution in 1853, and published the following year, Faraday said: "There is reason to believe we should derive much information as to the intimate nature of these non-metallic elements, if we could succeed in obtaining hydrogen and nitrogen in the liquid and solid form. Many gases have been liquefied; the carbonic acid gas has been solidified, but hydrogen and nitrogen have resisted all our efforts of the kind. Hydrogen in many of its relations acts as though it were a metal; could it be obtained in a liquid or a solid condition, the doubt might be settled. This great problem, however, has yet to be solved, nor should we look with hopelessness on this solution when we reflect with wonder—and as I do almost with fear and trembling—on the powers of investigating the hidden qualities of these elements—of questioning them, making them disclose their secrets and tell their tales—given by the Almighty to man."

Faraday's expressed faith in the potentialities of experimental inquiry in 1853 has been justified forty-six years afterward by the production of liquid hydrogen in the very laboratory in which all his epoch-making researches were executed. The "doubt" has not been settled; hydrogen does not possess in the liquid state the characteristics of a metal. No one can predict the properties of matter near the zero of temperature. Faraday liquefied chlorine in the year 1823. Sixty years afterward Wroblewski and Olzewski produced liquid air, and now, after a fifteen years' interval, the last of the old permanent gases, hydrogen, appears as a static liquid. Considering that the step from the liquefaction of air to that of hydrogen is relatively as great in the thermodynamic sense as that from liquid chlorine to liquid air, the fact that the former result has been achieved in one-fourth the time needed to accomplish the latter proves the greatly accelerated pace of scientific progress in our time.

The efficient cultivation of this field of research depends on combination and assistance of an exceptional kind; but in the first instance money must be available, and the members of the Royal Institution deserve my especial gratitude for their handsome donations to the conduct of this research. Unfortunately its prosecution will demand a further large expenditure. It is my duty to acknowledge that at an early stage of the inquiry the honorable company of Goldsmiths helped low temperature investigation by a generous donation to the research fund.

During the whole course of the low-temperature work, carried out at the Royal Institution, the invaluable aid of Mr. Robert Lennox has been at my disposal, and it is not too much to say that, but for his engineering skill, manipulative ability, and loyal perseverance, the present successful issue might have been indefinitely delayed. My thanks are also due to Mr. J. W. Heath for valuable assistance in the conduct of the experiments.

JAMES DEWAR.

"It is a notorious fact," says The National Druggist, "that the pineapple is considered the least healthy of all the edible fruits of the tropics by those who know anything of the matter. . . . The juice of the green and growing plant is accredited in Java, the Philippines, and throughout the Far East generally with being a blood poison of a most deadly nature. It is said to be the substance with which the Malays poison their krishes and daggers, and is also accredited with being the 'finger-nail poison' formerly in use among aboriginal Javanese women almost universally. These women formerly (or some thirty odd years ago), and possibly do yet, cultivate a nail, sometimes more, on each hand, to a long sharp point, and the least scratch from one of these was certain death."

* See Phil. Mag., 45, 525, 1898.

* "Proceedings," 1896, 14, 130.

* See Scientific Papers, 2, 412.

† See Faraday's Lectures on the Non-Metallic Elements, pp. 292-3.

THE COCHOT MOTOR-VEHICLES.

We illustrate herewith two light motor-vehicles recently introduced by M. G. Cochot, of 45 Rue Tanger, Paris. Fig. 1 illustrates a two-seated tandem car which is claimed to be an improvement on the ordinary quadricycle, inasmuch as the rear rider (the driver) is provided with a comfortable seat in place of being mounted on a saddle. Fig. 2 shows the Cochot two-seated sociable voiturette. Both cars are fitted with a vertical petroleum-spirit motor of the firm's own construction. It is of $2\frac{1}{4}$ horse power with electrical ignition and large radial disks for cooling purposes. The engine is geared to the rear axle, a two-speed gear being provided. A feature of the jack-in-the-box, or differential gear, is that it comprises no bevel wheels, but is composed of straight spur wheels only. Steering is effected by a hand wheel, while all the control levers are arranged within easy reach of the driver. The

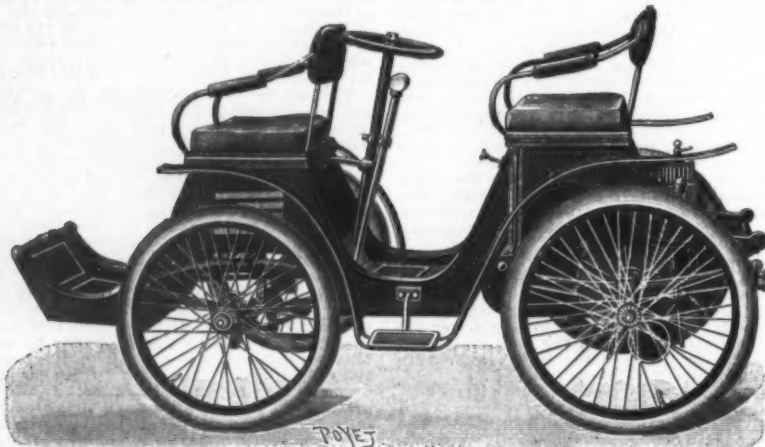


FIG. 1.—THE COCHOT TANDEM CAR.

voiturette (Fig. 2) can be provided with a small seat in front for an additional passenger, as shown, and at an extra cost can be fitted with a two-cylinder motor of 4 horse power. Ample brake power is available, while a point claimed for the hill-climbing gear provided is that all the wheels comprised in it are always in mesh. —We are indebted to The Motor-Car Journal for the engravings and article.

THE RELATIONS BETWEEN ELECTRICITY AND ENGINEERING.*

THE nineteenth century is distinguished in our profession chiefly by the knowledge we have obtained of the constitution of matter and of the qualities of the materials we utilize for the service of man, of the presence and the characteristics of that medium—the ether—which fills all space, and of the existence, indestructibility, and protean character of that great natural source of force, motion, work, and power which we call energy.

Electricity is only one of many forms of this energy. It is measurable in well defined and accurately determined units. It is produced and sold, utilized and wasted. It is, therefore, something distinctly

sight in positions known only to himself, and of applying it with great efficiency at the exact spot desired. No magician or poet ever conceived so potent a power within the easy reach of man.

THE DOING OF WORK.

The maintenance of an electric current through a conductor means the expenditure of work upon that conductor, and this expenditure of internal work means molecular motion. In solid conductors the result is heat. If the current be gradually increased, this motion is similarly increased. The result is successively incandescence, white heat, fusion, and disruption.

In liquid conductors the motion probably becomes revolution. The result is decomposition by the activity of the centrifugal force overcoming chemical affinity. The atoms fly away in fixed determined lines, and collect at opposite poles.

In gases the transference of electric energy in the form of sparks means dissociation. Compound gases are broken up into their component elements under the same directing influences. Work is done upon the gas as in the previous instances.

The principle of work that lies at the very root of the profession of the engineer enables all these operations to be measured in definite mechanical units, reducible to the common English standard, the foot-pound, but which the electrical engineer, with greater precision, refers to the scientific unit of work—the Joule.

THE PURIFICATION OF MATTER.

The elements and their useful compounds are rarely, if ever, found pure. Impurities have to be sifted away. Ores, raw produce, rocks, and earths have to be subjected to various processes of refining and conversion to extract from them that which is wanted. The electric current by the above operations has proved to be a powerful agent to break up crude materials into their useful and useless constituents. The electro-chemical industries of the world are very extensive.

According to Prof. Borchers, the eminent electro-metallurgist, the world manufacture of calcium carbide for the production of acetylene gas is utilizing a power

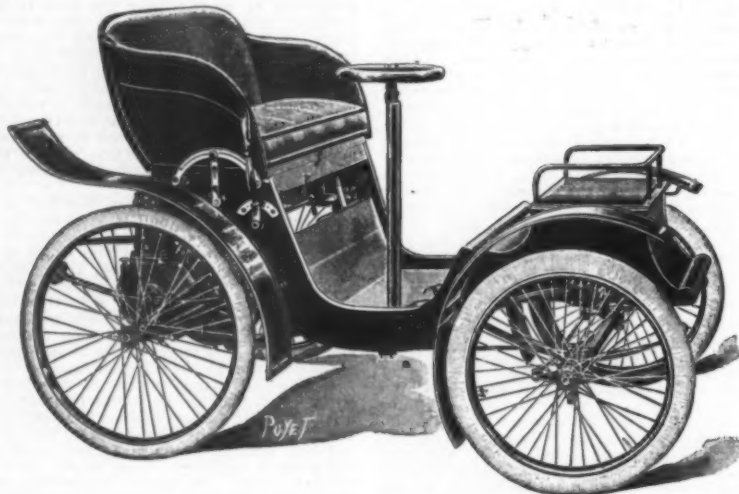


FIG. 2.—THE COCHOT VOITURETTE.

objective. It has even been defined by act of Parliament. There are four great principles underlying the practical applications of electricity:

1. The establishment of a magnetic field.
2. The establishment of an electric field.
3. The disturbance or undulation of the ether.
4. The work done by the generation and maintenance of electric currents in material systems.

Electricity as a science is fascinating to every one, but it is deeply fascinating to the engineer. The trustworthiness of its laws, the accuracy of its measurements, and the completeness and definiteness of the units to which its measurements are referred, give him confidence in his estimates and a certainty of the performance of his preconcerted operations. It places in his hands the means of directing the energy out of

* Condensed from the "James Forrest" lecture delivered at the Institution of Civil Engineers on April 23 by Sir William Henry Preece, K.C.B., F.R.S.

THE ANNIHILATION OF SPACE.

The elements of Volta and the battery of Galvani—zinc, copper, and a solution of sulphuric acid—gave a convenient generator of electric currents which could be directed along wires to great distances, and thus, by establishing magnetic fields, could deflect needles in such a way as to form the alphabet and so transmit words and, therefore, thought. In wires of great length, while the initial speed is that of light, it takes time for the electric waves to rise and fall, so that the number of currents which can be sent per second is limited. Between London and Liverpool the speed of speaking is virtually unlimited, but between Ireland and America it is restricted by the so-called capacity of the cable submerged in the ocean. This capacity absorbs energy and retards the rate of rise and fall of currents. While a thousand currents per second can be sent in the former case, only six per second are available in the latter.

Nevertheless, sitting on the shore of the Atlantic in Ireland, one can manipulate a magnetic field in Newfoundland so as to record simultaneously on paper in conventional characters slowly written words. Thus we have bridged the ocean and annihilated space.

The regulation of the ever-growing traffic on our railways and the safety of passengers is secured by similar means. The telegraph not only places the manager of the line in communication with every station upon his system, but electric signals control the motion of every train. A railway signal box is an electrical exhibition. Every line is protected by its own electric signal. Every distant outdoor mechanical signal is repeated back. The danger signal is locked, and cannot be lowered to "line clear" until it is unlocked by the train itself or by the distant signalman. Mr. F. W. Webb is not only working the outdoor signals themselves by electrical energy, but he is moving the points and switches by the same means. So far the experience gained at Crewe during a period of about twelve months from the working of a signal cabin containing about sixty levers has been such as to justify confidence and the extension of the system, and some ten cabins containing about one thousand levers will be provided. The apparatus has been designed to work in with, as far as possible, the standard signaling apparatus of the London and Northwestern Railway. The interlocking frame may be said to be the ordinary mechanical frame in miniature, occupying one-third of the space. The levers—about 6 inches in length—are placed in two tiers, and are manipulated in the same way as the levers of a mechanical frame; consequently the signalman accustomed to the old type has nothing to learn in the new. The levers are mechanically locked by means of tappet locking, and they control carbon switches by which the 110-volt electric current is transmitted to the motors.

The object of this electric working is primarily to reduce the manual labor of the signalman, and enable him to pay more attention to the movements outside his cabin; increased speed of working; the removal of obstructions on the ground caused by the numerous wire and rod connections necessitated by the present system; and, finally, a reduction in the number of signalmen employed. Thus electricity adds to the security of life. It supplies the railway man with a new sense, and the engineer with a new power.

The abridgment of time necessarily follows from the annihilation of space, but the chief element which saves our time so much is the fact that we can, by electricity, do so much more from one spot. Indeed, in the United States the railway companies complained that their revenue between New York and Chicago suffered through the introduction of the telephone. People remained at home and did their business by wire.

It is very curious when visiting the United States to find that their morning papers contain extracts from our London evening papers of the same day. One frequently receives messages in England that were sent off to-morrow. This is due to the difference in longitude.

Wireless telegraphy, or, as it is better termed, etheric telegraphy, has made but small progress, owing to the simple fact that the demands for its service are so very few.

TRANSMISSION OF POWER.

The sun is the fons et origo of all the available energy upon the surface of the earth. Coal and oil are extracted from its crust; oxygen is found in its atmosphere. Grasses, corn, fruits and vegetables become food and fuel for beast and man. Waters are converted into vapor, forming clouds, rain, brooks, rivers, torrents and falls. The atmosphere is disturbed by wind, and the waters of the ocean by tides. Energy is thus found available for useful work in many different forms. The problem before the engineer is how to select the best form of energy for his purpose, and how to utilize these waste energies of Nature so as to secure the best economical result. Falling water can, by a turbine or impulse wheel, convert the energy it possesses in virtue of its fall into the form of electricity. By the aid of transformers it can be raised to very high voltages; 40,000 volts is employed in California, 11,000 in Niagara. We use 10,000 between Deptford and Trafalgar Square. It can thus be transmitted to any reasonable distance, and there it can be utilized to do useful work. The waste forces of Nature are thus within our reach. The waterfalls of the Highlands may work the tramways of Glasgow; Niagara already works those of Baltimore.

The economy of this system for large industries is a question of the relative cost of the generation of energy by other means. Energy on the coal fields can be produced cheaper by burning coal than by any water scheme that I have yet examined in this country. The price and abundance of coal renders the transmission of energy to great distances at present a very limited question indeed. Where coal is scarce and dear and water abundant, as in Switzerland, water power is very much utilized. Where coal is abundant and cheap, as in England, it is uneconomical to adopt it. The transmission of power within limited areas by electricity in our cities is now within the range of practice. In Edinburgh it is supplied at the rate 1½d. per unit; this is 0.83d. per horse power hour. It is invaluable for small industries. It is there ready to be used when it is wanted; it wastes nothing while idle.

The economy and efficiency of distributing power

equal to 180,000 horse power; that of the alkalies and the combinations of chlorine for bleaching, 56,000 horse power; of aluminium, 27,000 horse power; of copper, 11,000 horse power; of carborundum, 2,000 horse power; and of gold, 455 horse power. Electroplating is one of the staple manufactures of Sheffield and Birmingham. There are nearly 200 firms working at the former place and over 100 at the latter.

The decomposing bath and the arc furnaces are revolutionizing many industries. Phosphorus is now being produced in England in large quantities from corundum, and aluminium from bauxite is extending in use and being reduced in price. The post office is using aluminium for telephone circuits. I have recommended its use on a very large scale in the interior of Africa, where transport is so costly. We can get the same conductivity as with copper with half the weight and at a less price, and we can put up a line telegraphically ten times better than of iron for less money.

over mills, factories and workshops by electricity instead of by shafting, gearing and belts, is so pronounced that the change is being effected in every country with great rapidity. If it were a question of the mere efficiency of the two systems, the advantage of the change would not be so obvious; but it is shown by the horse power hours expended, which means the coal bill. The efficiency of an electrical system is rarely less than 75 per cent., while that of shafting is frequently as low as 25 per cent.; but the economy is the continuous waste of the latter that tells on the coal bill, while in the electrical system there is no such waste. The motor runs when it is wanted, and expends only what energy is wanted for that particular work to be done. Electrical measurements are so exact and so easily applied that automatic records can be obtained of the work done by each machine.

Every up-to-date shop should have its electric plant for healthy light, cheap power and handy distribution of material. Its economy is demonstrable in the smallest, but in the largest shops it is at once most marked. It is always available, and it costs little. Ignorance or timidity restricts its use very much. The number of works that are run by electric motors in different parts of the country is very large indeed. The efficiency, handiness and economy of doing so is so marked that the practice is extending with great rapidity. Motors themselves are being daily improved.

On the Clyde and the Tyne, and, indeed, wherever shipbuilding is flourishing, there we find electrical energy driving machine tools, holding up plates, and assisting in various processes. In many large machine works, cranes and travelers are worked by it.

At Boston, Mass., crossing the Charles River and uniting Charlestown, the scene of the famous battle of Bunker Hill, with its headquarters, is a new bridge 100 feet wide and 1,920 feet long, having a draw of 240 feet span, weighing 1,300 tons. This draw is opened and closed by electric motors.

In the post office we have introduced electric motors very largely. At Leeds they are used for driving pneumatic pressure and vacuum pumps, employed there to work the pneumatic tube system. They are also used for working automatic stokers, ventilating fans and lifts.

TRACTION.

It is for traction purposes that electricity is making such gigantic strides. In the United States tramway working by its means has become practically universal. In the United Kingdom it is making rapid way, and in connection with electric lighting it is giving great economical results.

Electric railways are also growing apace. A bold attempt is being made by the Metropolitan Railway to work the existing line in such a way as not to interfere with the existing traffic or even with the permanent way. A new train of six coaches weighing 180 tons, having a motor car at each end weighing 54 tons, is about to run between Earl's Court and High Street, Kensington. Electric traction has an immense advantage over steam traction in impressing a continuous and uniform torque, or turning moment on the shaft, and consequently a continuous and uniform effort on the trend of the wheel. The action of the steam locomotive is intermittent and the bite not continuous. Hence, such frequent slipping on greasy rails. Again, the maximum torque can at once be applied by the current, and in combination with the constant effort it increases the acceleration so that a train acquires its maximum speed much more quickly. We shall increase the mean speed of the Metropolitan trains from 11 miles per hour to 15, and thereby increase the capacity of the line over 30 per cent. The stoppages on the underground railways are so frequent that the trains are always either accelerating or stopping. They never reach their top speed as they do on main lines. Electric traction enables them to start quicker and stop more promptly. On the Metropolitan the 180-ton train acquired 30 miles an hour in 200 feet, and, when going at the same speed, it was stopped in 130 feet—half its length. Smart work on such a railway depends on the rate at which trains can be emptied and filled. The English system of compartments and side doors facilitates this. It would be still further expedited if we could have one platform for entry, one for exit, and one class only.

The Liverpool and Manchester Lightning Express Railway, promoted by a very powerful representative syndicate two great commercial centers to carry out the scheme of Mr. Behr, is a very bold and promising venture. The line is to be mono-rail, 34 miles long, direct between the two cities, without any intermediate station and with no crossing. There are to be cars every 10 minutes. The speed is to be 100 miles per hour, and the time of transit 20 minutes. I know of no reason why this should not be done with safety and comfort.

The automobile car of the future has not yet seen the light. It will be electrical. Immense progress has been made in motors and in batteries. Lundell has shown how to store up the energy now wasted in descending hills, and to recover some of that absorbed by the inertia of the car. Although a battery has already been able to drive a car 100 miles with one charge, we are waiting patiently for the real automotor storage cell.

ELECTRICITY IN WAR.

A strong contingent of electrical engineers, under the command of Major Crompton, has volunteered for service in South Africa. They are all scientifically-trained practical young engineers. Bicycles, field telegraphs, telephones, arc and glow-lamps, cables, searchlights, traction engines and generating plant will be under their care. It is strongly hoped that we may soon hear good accounts of their performances at the front.

Electricity has been extensively applied to the development and utilization of explosives in both the civil and military divisions of our profession. Charges are safely fired under water and blasted in mining and demolition operations by small exploding dynamos, magnetic-electric machines or induction coils acting upon high tension fuses. Sir Frederick Abel has especially distinguished himself in this direction. His fuse, composed of phosphoride and subphosphide of copper, is universally used by our war department. Time guns are thus fired at stated hours at different sea ports by currents originating in Greenwich Observatory. Broadside in battleships and guns in turrets are

similarly discharged. Torpedoes are even directed by currents from the shore. The defense of our coasts by submarine mines and their explosion by currents when the enemy's ships are properly located by position-finders is the last development of the application of electricity to war.

Electrical blasting has revolutionized the operations of tunneling and driving galleries. It is much used in quarrying with great security to the men. The deepening of harbors and channels, and the removal of obstructions such as wrecks and rocks, are facilitated. On September 23, 1876, 63,135 cubic yards of solid rock were completely demolished by one discharge at Hell Gate in East River, New York. The preparation for this great blast took four years and four months. There were 4,437 charged holes, each containing its mercury fulminate fuse and charges of dynamite. There were 49,914 explosions used in that one blast. Batteries were used to generate the currents, and they were arranged in large groups. Each battery exploded 160 charges. This was the record blast.

The battleship is the home of electricity. It controls the rudder, it ventilates the interior and the living space of the ship, it forces the draught and assists the raising of steam, it revolves the turrets, it trains and controls the fans, it handles the ammunition, it purifies the drinking water, it lights up the ship internally, it enables the captain to sweep the horizon with the brilliant rays of the searchlight, and to communicate with his tender or with his commanding officer across space independent of weather, night, season, fog or rain.

SANITATION.

No branch of our profession fulfils the true function of the engineer more efficiently than that which deals



THE AUTOMATIC OPTICIAN.

with sanitation. Pure air, pure water, pure food, pure soil, pure dwellings, and pure bodies are the panacea for health and comfort. Electricity helps us very much in attaining some of these qualities. An electric glow-lamp does not vitiate the air. It does not throw into circulation in the air any product of combustion. The question of ventilation is very much reduced in importance and rendered more simple to effect. Much less air need pass through our sitting rooms and meeting places. The air vitiated by our lungs can be easily withdrawn and fresh air can be forced in by fans worked by electric motors. Even the air during its entrance can be warmed, and impurities floating in it can be sifted out of it by the attraction of electrification. Heating by Dowsing's luminous electric radiators is very much on the increase; they consume 250 watts, which cost about a halfpenny per hour. In many post-offices sealing wax is melted and kept in a liquid state by currents. Water can be sterilized by ozone, a product of electrification, and even by the nascent oxygen, when broken up into its constituent elements by electric currents. Sea-water thus electrolyzed supplies us with chlorine, and converts the water into a powerful antiseptic, disinfectant and deodorizer.

WEAVING.

The applications of electricity to other industrial processes are innumerable. I have time to mention only one. Mr. T. A. B. Carver has brought out a new Jacquard loom for weaving; 600 hooks are controlled electrically. The will as well as the pattern is under complete management. It has been warmly taken up in Glasgow, and a factory has been started there.

The pattern on this cloth is woven directly from a photoprint of the artist's design, mounted on a metallic sheet; the threads of the warp being picked up by the electromagnetic action, owing to the figure of

the pattern being cut away, and thus allowing the circuit to be completed by the metallic sheet.

DISTINCTION BETWEEN PHYSICISTS AND ENGINEERS.

There is now a distinct line of demarcation separating the physicist from the engineer. The former dives into the unknown to discover new truths; the latter applies the known to the service of man. Research is the function of the one; utility that of the other. In the past the engineer had to rely on himself for his facts, but the advance of modern science, the growth of technical education, the formation of laboratories, and the endowment of chairs have changed all that.

We can scarcely hope for new sources of energy to be discovered, but there are some existing ones we have not touched yet. When the evil day arrives for our coal supplies to give out we may perhaps be able by the aid of electricity to utilize the heat of the sun and the tides of the ocean. There is, however, a vast illimitable store of energy not only in the rotation of the earth upon its axis, but in the internal heat of this globe itself. As we descend, the temperature gets higher and higher. It ought not to be difficult to reach such temperatures that by thermo-electric appliances we might convert the lost energy of the earth's interior into some useful electric form.

THE AUTOMATIC OPTICIAN.

We illustrate herewith an apparatus which we have seen in operation in England, and which we shall call the "Automatic Optician," since that seems to be the name best adapted to it in view of the rôle that it has to perform. Its English name is, in reality, the "Automatic Sight-Testing Apparatus," the object of the instrument being to tell a person the kind and number of the glasses that his eyesight requires.

In external aspect, the apparatus bears considerable resemblance to the automatic scales and other analogous devices; but, above the pedestal in front of which the customer of the apparatus takes his position between the guards, there is a wide plate containing a slot for the reception of a coin, and two apertures to which the customer applies his eyes. Behind these two oculars, and inside of the box, is fixed a card upon which are printed extremely fine characters that are situated at a distance of 14 inches from the eyes. Inside of the box again, and between the oculars and the card of printed characters, there are two disks to which may be simultaneously given a rotary motion, and the periphery for each of which carries thirty-six glasses corresponding to the ordinary defects of vision of long and short-sighted persons. Consequently, when anyone wishes to know what glasses it is necessary for him to purchase, he puts himself in position in front of the oculars and looks through them while he turns to the left or right a button placed at the bottom of the right hand side of the box. After turning this button until he sees the printed characters as distinctly as possible, all that he has to do is to read a number that makes its appearance at the same time.

Of course, since the glasses for short and long sighted persons, do not, in reality, form an uninterrupted series of numbers that succeed one another, it is unnecessary to say that the number that is read thus corresponds to a peculiar classification which is made for and by a special house. The fact is that the apparatus under consideration were devised by a manufactory of optical glasses styled the Automatic Sight-Testing and Optical Supply Company, for the simple reason that it got up these sight-testing apparatus and furnishes the public with the glasses corresponding to the numbers above mentioned.

After the customer has read the number of the glasses that he requires, all that he has to do is to detach a printed sheet that hangs within his reach, and which is an order provided with a blank space for the reception of the number in question, and also a space in which to write the number of spectacles or eyeglasses needed, and a specification as to whether they are to be used for reading or for seeing at a distance.

Of course, this automatic apparatus is not designed entirely to replace the oculist and optician; and if the patient does not find something in the "Automatic Optician" to suit his sight, all that he has to do is to address the company just mentioned, which will send him a card directing him to a specialist or a hospital.—*La Nature.*

MACCARONI MANUFACTURE IN ITALY.

HER MAJESTY'S Consul at Naples gives the following account of the manufacture of macaroni in that district: Macaroni is made of hard red wheat from the Black Sea, mixed with Italian wheat, grown mainly in the plains round Foggia. This is ground into semolina (not flour), the bran and husks are removed, and the semolina kneaded in hot water till it has the appearance and consistency of dough. The dough is then placed in a vertical brass cylinder, about 8 or 9 inches in diameter, the bottom of which is a plate like the rose of a watering-pot, which is fine or thick, according to the macaroni required.

Thus, for making vermicelli and all kinds of solid macaroni, the holes are very small, while for making the tube macaroni the holes are much larger. In the latter case also a conical blade is fixed in the middle of the hole to form a tube. The dough being placed at the top of the cylinder, it is driven down by hydraulic pressure through the perforated plate and cut off by hand in lengths of about 3 feet. It is then hung on canes in the sun to dry. In the case of the solid macaroni there is no difficulty in grasping the process. In the case of the tubular macaroni the conical blade and its attachment cut through the dough and the macaroni issues with a slit all along it. This, however, shrinks together at once and forms a perfect tube, the join being practically invisible.

No macaroni is now made by the laborious hand process.

There was for a long time a prejudice against machinery, but this has been overcome.

About a million boxes are sent annually to the United States, and about ten thousand to London. The remainder is sold in Italy.—*Board of Trade Journal.*

THE MEANS OF DEFENSE OF ANIMALS.*

I. THE STRUGGLE FOR EXISTENCE.

THE word "defense" implies a struggle; and in endeavoring to form a large and comprehensive idea of the means of defense of animals it is necessary to appreciate how great and how intense is the struggle for existence in which those means of defense are employed. Darwin remarks that "Nothing is easier to admit, in words, than the principle of the universal struggle for life, or more difficult (at least, I have found it so), than constantly to bear this conclusion in mind; yet unless it be thoroughly ingrained in the mind, the whole economy of nature, with every fact on distribution, rarity, abundance, extinction and variation, will be dimly seen, or quite misunderstood. We behold the face of nature bright with gladness; we often see superabundance of food; we do not see, or we forget, that the birds which are idly singing around us mostly live on insects or seeds, and are thus constantly destroying life; or we forget how largely these songsters, or their eggs, or their nestlings, are destroyed by birds and beasts of prey; we do not always bear in mind, that, though food may now be superabundant, it is not so at all seasons of each recurring year." He continues: "I use this term (struggle for existence) in a large and metaphorical sense, including dependence of one being upon another and including (which is more important), not only the life of the individual, but success in leaving progeny." He bids us "keep steadily in mind that each organic being is striving to increase in a geometrical ratio; that each, at some period of its life, during some season of the year, during each generation, or at intervals, has to struggle for life and to suffer great destruction."

When we try to realize the struggle for existence (and we shall make this attempt in a few minutes) we cannot fail to be impressed with the high rate of mortality that prevails among many animals. So many perish by the perils of land and sea, earth and sky, that we begin to wonder how any succeed in leaving a new generation behind them; yet, in the great majority of animal species, a considerable number of individuals do so succeed. The means whereby they succeed are their means of defense. These means of defense are the subject-matter of this course of lectures; and their scope can probably be most concisely stated by saying it includes all those things that make for life.

We proceed now to look into the struggle for existence as a necessary preparation for a right understanding of the means of defense. Why does the struggle for existence take place? There appear to be four chief causes:

- I. The geometrical rate of increase of all living beings, and the consequent competition.
- II. The limitations of the food supply.
- III. The reciprocal relations of food and feeders.
- IV. The climatic limitations of each species.

We shall probably be justified in regarding these causes as of different degrees of importance, corresponding to the order in which they are here mentioned, "I." being the most important.

I. The geometrical rate of increase refers, of course, to the fact that almost all living things that have the power of reproduction, produce many offspring, with the result that as each generation dies the next generation is much more than able to replace the dead, at least in point of numbers. It is also to be remembered in this connection that the sole object of life in many a plant and many an animal seems to be the forming of a new generation. This is shown by the death and decay of many plants as soon as they have sown seed, even though this may occur in early summer, when neither excessive nor insufficient heat can be considered as the cause of death. Such plants are flax and morning glory. Additional evidence has been experimentally obtained by preventing the fertilization of flowers, with the result that those blossoms retain their form, color and freshness much longer than they would if the fertilization of the ovules were not prevented. Moreover, the death of many animals (and here may be mentioned such forms as May-flies, many of the parasitic worms, etc.), is determined by the fulfillment of the reproductive instinct. These cases cited prove, not that the fulfillment of reproduction is the cause of death, but that, ordinarily, the life of the individual is prolonged until reproduction shall have been accomplished. This view is confirmed by the well-known fact of the existence of parasites, such as *Trichina* (of the group of the threadworms), where the worm will exist for many years—perhaps even as many as twenty—in its latent, or dormant, condition; and yet these worms, when brought into proper conditions, complete their development and produce young.

The numerical value of the rate of increase varies enormously in different animals. It evidently depends not only on the number of offspring which each individual is capable of producing, but also on the period when that individual begins to reproduce and on the length of time during which the reproduction is maintained. Thus, the plant-lice, or Aphides, so common on all sorts of plants, both cultivated and wild, have always had a great reputation for their enormous increase and the rapidity with which this increase takes place. Here the great increase is due not so much to the fact of each individual female producing a great number of eggs, but rather to the circumstance that each individual female begins to reproduce early, and continues to do so for a considerable number of days, which is a large part of the entire life of the individual. For example, observations on the apple-tree plant-lice, made in Ohio and published by Mr. Webster, in 1893, make this apparent. Plant-lice are viviparous; and reckoning from the time of birth in each case, Mr. Webster found that a winged female may commence bearing when only seven days old, and produces twenty-four young in the subsequent eleven days of its life. The wingless females are more prolific; they bring forth their first-born when six or seven days old; and cases are known where one female produced sixty-five young in nine days; another, fifty-nine young in nineteen days; and since this species also lives over the winter in the wheat fields (at least, during mild winters), and females have been found reproducing in every

month of the year, it is evident how, in a very short time, the total number of individual plant-lice is increased enormously.

For the probable minimum rate of increase we recall Darwin's statement as to the elephant, which is believed to be the slowest breeder of all animals. Here, six young are produced in the period of sixty years, which intervene between the thirtieth and ninetieth years of the parent.

Leuckart gives the number of offspring of a single *Trichina spiralis* as 1,500. These young are born in active condition, during a period of from five to six weeks; so that there is, on an average, one birth to each half-hour. Mr. R. S. Earle some years ago made extended observations on the codfish on the coast of Massachusetts. He found that a female codfish reaches maturity at the age of four years, by which time it may have attained the weight of 5 pounds. "Evidence is not wanting to show that a codfish spawns every year, and that it deposits the entire number of eggs in the ovaries every year." The eggs ripen slowly through a period of six to ten weeks, at least. The spawning period extends over fully nine months in each year. The number of eggs in the ovaries depends on the weight of the individual. In a 31-pound cod there were 2,782,287 eggs; in a 70-pound cod, 9,100,000. Unfortunately, the weight of a codfish furnishes no approximate clue to its age; so that there is no means of determining how old a 70-pound codfish may be; but taking the slowest rate at which codfish have been observed to grow, and the smallest number of eggs proportionate to the pound in the total weight of the fish, we shall probably be safe in asserting that a 70-pound cod is at least 20 years old and has shed, during its lifetime, 76,800,000 eggs.

One of the most prolific individuals is the American oyster, of whose eggs Prof. Brooks says that 9,000,000 is probably less than the true number in a medium-sized female; while in an unusually large female about 30,000,000 eggs in the probable number. Of the rate of growth of the oyster, Prof. Ryder says that "In order that the oyster may attain the great size of certain single individuals that I have seen, it may take even ten years. I should think it would take at least that length of time for an oyster to grow until its valves would measure nine inches in length." Elsewhere he states that oysters twenty-three months old, and 2½ inches long, are found to have the reproductive organs active and that they contain ripened spawn. If we assume "the unusually large" oyster of Prof. Brooks to be 9 inches long (which is quite a safe estimate), and further assume that this oyster had been breeding for eight years, it seems possible that during that period the oyster had shed 240,000,000 eggs.

II.—The limitations of the food supply. In spite of the continuous need of food by all animals which are not in a condition of latent life, it is extremely difficult to point out cases where famine alone operates, under natural conditions, to increase the severity of the struggle for existence. In many cases where death from starvation occurs, it is not alone the absence of food that causes the animals to perish, but usually some climatic condition, which is combined with the absence of food—such, for example, as the deep snow-storm which covers it. We have, however, sufficiently explicit and precise data as to the effects of famine upon man: as, for example, in Paris, during the last 110 years. Occasionally, death by famine takes place on a large scale—as in an instance (which is quoted by Wallace in his "Darwinism") observed by Edwin Clark. He states that at the time of one of the droughts in the Argentine Republic, "no less than 50,000 head of oxen, sheep and horses perished from starvation and thirst, after tearing deep out of the soil every trace of vegetation, including the wiry roots of the pampas grass."

The disastrous effects of a limited food supply are also to be seen in the life-history of parasites which are not introduced into their proper hosts. Thus, Cobbold repeatedly fed trichinized flesh to a variety of animals, and subsequently examined their corpses to ascertain whether the parasites had developed or not. This was found to be the case in dogs, guinea-pigs, hedge-hogs, cats and pigs; but in no case did the trichina develop in sheep, or in birds.

As another illustration, we have, in the United States, a species of butterfly, *Phyciodes tharos*, the caterpillar of which is extremely limited in its diet. Dr. Scudder is authority for the statement that it feeds only on a single species of aster—*A. novae angliae*. It is true, in general, that each species of caterpillar, if it is not absolutely restricted to a single species of plant for its food, is, at least, dependent upon a limited number of kinds of plants which are all more or less related to one another. The limitations of that food supply vary greatly in different species. The French entomologist, Fabre, tells of a late frost in France, which, touching the opening leaves of the mulberry, deprived the newly hatched silk-worms of their food. He was appealed to by his silk-worm-raising neighbors to find a substitute. He presented the tender leaves of the elm, the nettle-tree (the nettle and the pellitory, belonging to the same family as the mulberry, or to the family nearest to it). Other plants, whose affinities were less close, were also tried, but all in vain: the silk-worms refused all, and died of hunger. On the other hand, Fabre made experiments with a number of insect-feeding wasps, where the young feed upon insects which have been paralyzed by a sting from the mother; and, ordinarily, each species has a definite kind of insect food. Thus he found that one of these forms, known as *Bembex*, normally feeding on two-winged flies, was able to rear successfully by feeding the young on locusts; in the genus *Ammophila*, whose menu ordinarily consists of measuring-worms, the young took kindly to small spiders; *Pelopon spifex*, which is ordinarily a consumer of spiders, feasted on tender locusts; *Cerceris arenaria*, a passionate lover of weevils, was contented with alder-bees; so that it is quite evident that the limitations of the food are very different, or, rather, the limitations which food imposes upon different species, are very different.

Still another important influence of the food supply on the struggle for existence is that the quantity of food determines, to a great extent, the size of the reproducing individual. We have seen that in the case of the ood the number of eggs increases with the weight of the fish; and there is much reason for be-

lieving that differences in the weight of different codfish are due rather to differences in the food, than to differences in the age. It follows, therefore, that while the food in a given locality might not be so scarce as to lead to actual starvation of the individuals inhabiting that locality, yet they might produce much fewer young, and, therefore, not succeed so well in their struggle for existence as in the case of other individuals of the same species which live in richer feeding-grounds.

III.—The reciprocal relation of food and feeders is a statement that every animal which feeds upon plant or animal food is itself the food of plants or animals. Even of civilized man is this statement true; for whenever he suffers from diseases produced by germs or parasites, he is the food of plants (namely, bacteria), or of animals, such as trichina. This reciprocal relation is of great importance; and Darwin has given the famous illustration of the relation existing among clover bumble-bees, field-mice and cats—that the clover depends for its fertilization on bumble-bees; bumble-bees are fed upon by field-mice; field-mice are preyed upon by cats and in the neighborhood of towns, where cats are more abundant, the mice suffer more, and, therefore, the bumble-bees are less preyed upon by the mice, and hence have a greater chance to fertilize the clover.

Other and similar observations are not wanting. Mr. H. W. Wenzel, an excellent field naturalist, and a member of this academy, tells me that a few years ago, at Angelsea, New Jersey, at a time when mosquitoes were abundant and annoying, a large flock of dragon-flies pursued and fed upon the mosquitoes; but, unfortunately, not long after these had put in their appearance, a considerable flock of gulls appeared and fed upon the dragon-flies.

The history of the Tussock-moth, in the city of Washington, in 1885-6, as related by Dr. L. O. Howard, also affords an interesting illustration. In the summer of 1895, the Tussock-moth caterpillars stripped the leaves off almost every poplar, soft-maple, box-elder, alder, elm, birch and willow in the city; while other trees were badly damaged; parasites, however, (chiefly Hymenopterous and Dipterous insects) increased, stinging the caterpillars and laying their eggs inside of them, so that by early September of 1895, 90 per cent. of the caterpillars were affected, and consequently never produced any moths. The remaining 10 per cent. however, yielded moths in the latter part of September; the females among these laid eggs which lived through the winter and in April and May, 1896, "a moderately abundant hatching of young caterpillars" took place. But the parasites of the previous year had also successfully lived over the winter and now appeared in great numbers, so that by June, 1896, almost all the caterpillars of the Tussock-moth were parasitized and, consequently, failed to produce moths. In the latter part of the summer of 1896, Hyper-parasites appeared, which preyed on the first group of parasites; the effect was so marked that in the late summer of 1896 the number of caterpillars increased again. To summarize and be precise, the Tussock-moth caterpillars were preyed upon by (among other insects) an Ichneumon-fly known as *Pimpla*; *Pimpla* itself was parasitized by another insect known as *Dibrachys* and, finally, *Dibrachys* in several cases, was proven to be parasitized by *Aseodes*; so it follows that whenever *Aseodes* and *Pimpla* were abundant, the numbers of the Tussock-moth were decreased; while increase in numbers of *Dibrachys* was favorable to the increase of the Tussock-moth.

IV.—The climatic limitations of each species. When we think of the geographical distribution of living things, it seems quite natural to account for the occurrence of certain species in limited parts of the world as being due to the effects of temperature. We have become so accustomed to think of the tiger as an inhabitant of the warm parts of Southern Asia, that we are surprised when we first hear that it is also at home on high and cold mountains such as Ararat, the Caucasus, the Elburz and the Altai, and that its tracks have been observed on Himalayan snows, at an altitude of 6,800 feet.

Again, when we recall that many animals have been introduced into regions of the earth previously uninhabited by them, and have spread themselves over extensive areas within a short time, it is still more evident that climatic conditions cannot be as important factors in the success or failure of each species as may at first sight appear. This applies to such forms as the English sparrow and the European cabbage butterfly, which have spread over the greater part of North America within a period of thirty years, and it is, therefore, evident that, in these cases, just as in the case of the tiger, climatic limitations have very little to do with the struggle for existence.

After excluding cases like these, which can be shown to be other than examples of climatic effects, marked instances of such effects upon the struggle for existence can be pointed out.

In the vicinity of Berlin, Germany, there are two species of frogs. The common frog spawns in March and April, the edible frog in May and June. Prof. Oscar Hertwig has experimented upon the temperatures at which these eggs develop. He found that the eggs of both species will live in water at the freezing point, although they do not develop in water of that temperature, and if they had previously commenced to develop, such development ceases. If the temperature rises above that of the freezing point, development takes place within the limits of 3° to 27° Centigrade in the case of the common frog, and from 2° to 33° Centigrade in the case of the edible frog. Now it is the common frog which spawns in the two earlier months; the edible frog in the two later months, and, consequently, the edible frog is naturally exposed to higher temperatures than the common frog. Prof. Hertwig also found that, if the temperature exceeded, even by 1° Centigrade, the maximum which has just been mentioned for each of these species, the eggs were killed; if there was only a slight increase of less than a single degree over the maximum in each case mentioned, the eggs tended to produce abnormalities. It is, therefore, quite evident that a sudden rise of temperature, an unusually warm spell in these months, could very easily cause the death of the eggs of these two species.

An interesting case of temperature limitation among fishes is related by Knauth, of certain individuals of the European fish *Tinea*, which, at the age of five

* Lecture delivered at the Academy of Natural Sciences of Philadelphia, by Philip P. Calvert, Ph.D., of the University of Pennsylvania. Copyright, 1900, by Philip P. Calvert, Ph.D. Revised by the author for the SCIENTIFIC AMERICAN SUPPLEMENT.

months, were placed, in the year 1888, in a millpond of flowing water, where the temperature, even in the hottest days of summer, did not exceed 16° Centigrade. In March, 1893, these fish were transferred to a shallow pool in which were living (and have been living ever since 1888) a number of fishes of the same brood, hatched at the same time. The newcomers and the old residents lived there healthily and contentedly until July, when the temperature reached 25° Centigrade; the newcomers began to die, but the old residents were not affected in the least. At 27°, all the newcomers were dead, but all of the old residents were quite alive and active, and they were not affected by the increase of temperature until 35° Centigrade was attained.

The presence or absence of moisture is another climatic condition of great importance. Countless numbers of tadpoles die annually from the drying of the shallow pools in which the eggs from which they hatched were deposited. Eggs of many marine animals east up on the beach dry and die.

Observers in different parts of the world so widely separated as Illinois, France and Russia are agreed that humidity is a necessary condition to the existence and propagation of the Hessian fly, a dangerous enemy of wheat and other grains; while, on the other hand, the chinch bug (also an economic pest), only spreads when the temperature is high and moisture is absent.

Among climatic limitations are also to be included the effects of sediment in flowing streams or in ocean currents. For example, in the case of coral reefs, which parallel so many coasts, it is found that there is always a breach in the reef opposite the mouths of fresh water streams, and that the reason why the seamounts occur seems to be that the sand and mud brought down by these streams into the ocean so cover up the coral polyps as to prevent their living in this space, and hence also prevents their forming coral.

Having briefly analyzed the effects produced by each of the four mentioned causes, we have now to attempt to understand how they act simultaneously. For it is true, in this aspect of nature, as in every other, that almost every phenomenon is not the result of one single cause, but the effect of many combined. Just as the movements of the planets, for example, are due to a composition of forces, so the struggle for existence is due to the combined action of these various causes which we have discussed.

The high, natural rate of increase in animals results, usually, in a large number of offspring. If all the offspring of a single parent begin their development in the same place, a competition is at once set up between them for the food which is available. If the food supply be large relatively to the number and needs of these offspring, then the fraternal competition is slight; but in many cases where other food is absolutely unobtainable, the severity of the struggle reaches its height in cannibalism. But the competition for food may not only be with one's fellows, but with other species having the same diet.

Gregariousness tempts enemies with the prospects of a large amount of food to be obtained with little labor; while, on the other hand, it may afford protection which numbers alone can give. It rarely happens that the structure and habits of a given species protect it equally well against all the adversaries to which it is exposed. If, therefore, the food supply fail when the animal is unable to seek for it elsewhere, or an enemy appear when flight and fight are alike impossible, or a climatic change occur with a suddenness that admits of no adaptation thereto, then all of the successes of the previous life are lost, and the individual falls in the struggle.

It is extremely difficult to determine the rate of mortality among animals. Most of the data are based on individuals reared under conditions more or less artificial, and protected, to a considerable degree, from many adverse circumstances ordinarily existing in nature. The difficulty of obtaining information on this subject from animals in purely natural conditions is self-evident; since this would involve examinations of individuals scattered over considerable areas, and their identification for future record. Consequently our estimates of the proportion of those who, dying before maturity, fall in the struggle for existence, are little more than guesses. Nevertheless, we must use them in default of anything else.

From records of the number of half-grown oysters found in association with full-grown individuals, Moebius believes that only one newly hatched embryo in every 1,041,000 survives to reach the half-grown shelled condition. This is a death-rate of 99.99991 per cent. The figures are for the European species, in which the number of eggs is about one-ninth of that of the American species. For the Lepidoptera, Mr. C. S. Westcott, an associate of this society, who has paid much attention to rearing them in captivity, and to observing them under natural conditions, has kindly furnished me the following: "I have several times counted the eggs laid by a female to determine the number approximately, and have found *Ayantra cunia* to lay over 800. This species (which has two broods in this neighborhood), is about ten times as numerous in the second as in the first brood. Allowing each female to lay 800 eggs, this would mean that of the first brood one female to every 80 eggs completes its life, and in the fall brood, only one female to every 8,000 eggs. I once had a call for a large number of *Pyrausta nuntia*, (a common butterfly of this region) and collected over 300 larvae. Every one of these larvae changed into pupae; but out of the lot I got only one butterfly: every other chrysalis developed a parasite, these parasites being all of the same species. On another occasion I found about 75 larvae of *Melitaea phaton* butterfly, and nearly every one produced a perfect insect. The loss was very small."

Again, in the forest tent caterpillar, (which has been very destructive this last summer in the State of New York), the rate of mortality is estimated as about 41 per cent. Among fishes we note great mortality in the very early stages of their existence. Thus, Dr. J. P. Moore reports that in the eggs of the cunner collected at the surface of the sea during the summer of 1897, fully 30 per cent. had failed of being fertilized. Mr. Earl's opinion in regard to the cod is that probably but a very small number out of a million cod eggs are successfully hatched; and, of the young fish but very few reach maturity.

Probably every group of animals has many advers-

ties to contend with. In the past, whole classes of animals have been exterminated, which means a rate of mortality of 100 per cent.; some species are even now passing away; yet, of the great majority of animals now living on the earth, after allowing for the annual variations of increase and decrease, it is probably true that they are holding their own.

How do they hold their own? The answer is to be found in a consideration of the means of defense—all those things that make for life.

Just as we have recognized four chief causes of the struggle for existence, so we propose to treat of the means of defense under four headings, corresponding to the defenses which exist against those four several causes. So we shall consider: firstly, the protection of the young; secondly, the protection of the food supply; thirdly, the protection against living enemies; and, fourthly, the protection against climatic changes.

THE SHRINKAGE OF LAKE NICARAGUA.

A QUESTION OF PERMANENCY OF THE PROPOSED NICARAGUA CANAL.

BY ANGELO HELPRIN, F.R.G.S., F.G.S.A., late President of the Geographical Society and Professor of Geology at the Academy of Natural Sciences, Philadelphia.

A VERY serious aspect of the proposed Nicaragua Canal, and one that has so far escaped earnest consideration, is that which pertains to the permanency of the waters of Lake Nicaragua, the fountainhead of the San Juan River. The canal which intends to use the lake as the feeder to its high level must necessarily have this permanent, and if it cannot be held so, there can be no permanent canal. In a paper published in the SCIENTIFIC AMERICAN, of February 24, 1900, entitled "An Assumed Inconstancy in the Level of Lake Nicaragua," and further elaborated in the pages of the bulletin of the Geographical Society of Philadelphia for March, "The Nicaragua Canal in its Geographical and Geological Relations," I have given what appeared to me good reasons for believing that the level of the lake is inconstant, and that the waters had dropped from 15 to 20 feet in the period of little more than half a century or less. This conclusion is supported by the earlier determinations of altitude made by the Spanish engineer, Galisteo, in 1781, and the English engineer, Bailly, in 1838, the results of which differ from those obtained more recently in the American surveys by some 20 to 30 feet. In a paper having the same title as my own, published in The National Geographical Magazine for April, Mr. C. Willard Hayes, of the U. S. Geological Survey, and geologist to the Nicaragua Canal Commission of 1897-99, attempts to refute my conclusions, and asserts that "notwithstanding these earlier determinations the level of Lake Nicaragua has remained constant except for slight seasonal fluctuations, at least for a period whose length has to be measured in centuries," and "that the geologic conditions in this portion of the Isthmus are such that they afford a promise of future stability, and that the region is, therefore, favorable for the construction and maintenance of a work such as the proposed Nicaragua Canal" (p. 161). Mr. Hayes concedes that a region subject to the change which I have indicated "would offer serious obstacles to the construction of a canal of the magnitude of the one proposed or to its permanency after construction" (p. 156).

A critical examination of Mr. Hayes premises shows them to be far from conclusive, while the data presented in the official report of Chief Engineer Wheeler, of the Nicaragua Canal Commission, effectually dispose of his contention as to the lake's stability, and confirm the argument which has been advanced for its instability. Mr. Hayes gives three causes, singly or in combination, "which might bring about a change in altitude of the lake surface: (1) A depression of the whole of this portion of the Isthmus without warping; (2) a depression of the lake basin by warping, the sea margins remaining constant; (3) a cutting down of the lake outlet" (pp. 156-7). Not finding direct evidences of these causes, the case is considered to have no standing.

To many geologists, other causes beside the three that have been brought forward will suggest themselves as being able to bring about the result which has been indicated, and in a way equally as simple and effective as those which Mr. Hayes names. Of such, one need hardly go beyond the obvious one of a shrinkage in the supply of inflowing water.*

It is hardly necessary to traverse the arguments, based upon characteristics of flood-plains, the presence or absence of lake beaches and terraces, shore deformations, etc., upon which Mr. Hayes relies to prove the non-existence of his three causes; geologists know how illusory are "landmarks" of this kind in their negative condition. Nor need any particular weight be attached to the testimony of observations made or not made on the local phenomena by the inhabitants of a region, the particularly history involved in which dates to a period of fifty or sixty years back. When one realizes how many years were required to prove and disprove the difference of level of the two oceans on the opposite sides of the Isthmus of Panama; to prove and disprove the rise and fall of the land on the northern shore of the Bay of Naples in the classic ground of the Temple of Serapis; to prove and disprove that Mount Hood, a volcano standing almost on the outskirts of a populous town, was in energetic eruption in 1875; to prove or disprove that the famous Calaveras skull was found where it was found, etc., one need, perhaps, hardly assent to the proposition that in a region like Nicaragua some of its more pregnant phenomena "could not possibly escape notice"† and that lacking observational facts indicating an abatement of the waters of the lake, none such could have taken place. As a matter of fact, however, bearing upon the condition of Lake Nicaragua, emphatic testimony to the lowering of its waters is given by the

English engineer, Collinson, who ran a partial survey in the region in 1867; and in his report to the Royal Geographical Society, he further states that "even the least observant native, dwelling on the lake, will tell how its banks are rising year by year visibly before his eyes, etc.," and, thereby, whether accurately or inaccurately, supplements his own observations by an appeal to the observation of native sources. It is hardly necessary at this time to inquire into the credentials which Mr. Collinson bore as an engineer; suffice it to say, that there is enough evidence to show that in his day, whether his researches in Nicaragua were correctly or incorrectly made, he was considered a very competent observer; and his conclusions regarding the lake appear to be abundantly confirmed by the data furnished in the special report of the chief engineer, appended to the official report of the Nicaragua Canal Commission of 1897-99.

From this report it is made very plain that the intake of Lake Nicaragua, i. e., the rainfall on its surface, and the water that it receives from its full drainage basin, is for a run of years, and apparently for almost every year, less than the output, i. e., the loss due to evaporation and outflow. Indeed, in exceptionally dry years, the evaporation alone more than covers the entire intake.‡ From the observations made at a number of stations on the lake, it would appear that the annual rainfall over its surface is within about 28 per cent. of that at Rivas, while the inflow collected from the enclosing drainage basin is somewhat less than this amount, or 30 per cent. of the full rainfall over a region that has an area about three times that of the lake.‡ These data, with a knowledge of the amount of evaporation and the outflow, permit of an easy determination of the hydrodynamics of the lake. The evaporation from the surface of the lake is stated to be on an average of 6 inches per month during the dry season, and 4 inches in the wet. In 1868, the full evaporation for the year was 53 inches, but that year was considered to be "an abnormally wet one, and it is, therefore, probable that the evaporation was somewhat below the average. Mr. Davis (the hydrographer of the commission) estimates a normal annual aggregate at about 60 inches, or 5 feet.¶

The following absolute rise in the level of the lake as computed from a possible rainfall at Rivas is furnished by the engineers of the Canal Commission:

A rainfall of 30 inches would cause a rise, were there no evaporation or outflow, of.....	34 inches.
A rainfall of 40 inches do do.....	48 "
" " 50 " " " ".....	63 "
" " 60 " " " ".....	78 "
" " 70 " " " ".....	93 "
" " 80 " " " ".....	109 "
" " 90 " " " ".....	125 "
" " 100 " " " ".....	141 "
" " 110 " " " ".....	157 "
" " 120 " " " ".....	173 "
" " 130 " " " ".....	189 "

From November 1, 1889, to June 1, 1891, a period of 19 months, the total rainfall at Rivas was 38.39 inches, which would have raised the level of the lake 45.75 inches. The evaporation alone during this time would have lowered it 95 inches, an absolute loss to the lake, beyond what would be entailed by the outflow through the San Juan River, of over 4 feet. This, it is true, was the driest period observed, but the condition is said to be "not at all anomalous." From the beginning of December, 1884, to the end of April, 1886, a period of 17 months, the total rainfall at Rivas was 37.43 inches, which amount would raise the level of the lake 44.4 inches. The evaporation for the same period is assumed to have been 84.25 inches, a net loss to the lake from this source alone of 3 feet 4 inches. From the beginning of November, 1894, to the end of April, 1896—19 months—the rainfall was 45.15 inches, which would put a credit of 55.72 inches to the lake. The evaporation for the same period was 95 inches, a loss to the lake again of 3 feet 4 inches. The loss to the lake during three dry spells, calculated from the excess of evaporation over rainfall and inflow, and without taking count of the natural outflow through the San Juan River, was, therefore, 10 feet 10 inches. The report judiciously and significantly adds: "The recurrence of such dry years shows that they are to be expected in the future and should be provided for."§

It is self-evident that unless there are special compensations to the lake for such losses, the losses must be perpetual; and the compensations sought for can only be found in years or periods of extraordinarily heavy rainfall. The problem of restoration, therefore, rests entirely with the question of such periods occurring or non-occurring. The reports of the Chief Engineer and Hydrographer of the Canal Commission plainly state that they have not occurred.

Despite the fact that following rapidly on excessive rains the surface of the lake has been known to rise as much as two feet in six weeks, the greatest net accession to the lake for an entire year, and through a period of 30 years, was considerably less than two feet. This was in the year 1897, when the rainfall at Rivas during the 164 days between May 17 and October 27, was 112.43 inches.—"the period of greatest rainfall shown in the Rivas records since 1879. . . . This then (148.58 inches) is the estimated amount of fluctuation that would have occurred during the period of greatest rainfall of the last 20 years, if there had been no evaporation on the lake or outflow from it."¶

The year 1898, when the rainfall at Rivas was 108 inches, was almost, or quite, as favorable as 1897, and the net rise in the lake was 18 inches. The evaporation from the lake was during that year 53 inches, and the outflow through the San Juan, 84 inches—the lake, therefore, throwing off 11 feet 4 inches. Had there been no evaporation or outflow, the lake would have risen that year 154 inches.** Taking the outflow of 84 inches to be about normal for the lake standing at, or but little above, mean stage of water—elevation 104 to 106 feet—with a steady evaporation of from 50 to 60 inches, it is made impressively clear that many successive years of heaviest rainfall would be required to

* During the dry season, the evaporation exceeds the inflow. During exceptionally dry years, exceeds the inflow for the entire year. Report Chief Engineer Wheeler, page 58.

† Report Nicaragua Canal Commission, page 19.

‡ Report Nicaragua Canal Commission, page 18.

§ Report Chief Engineer, page 66.

¶ Report Chief Engineer, page 66.

** Report Nicaragua Canal Commission, page 81.

Report Nicaragua Canal Commission, page 18.

* In a future paper I shall discuss the subject of the engulphment of the lake and the nature of the Rivas plain.

† When in 1890 I announced, as the result of my barometric observations, that Ixtacchual, a mountain standing only 40 miles from the city of Mexico, measured in height little short of 17,000 feet, instead of being 15,600 feet, the statement was met with the proper objection, that if the mountain in reality was so close a competitor with Popocatepetl, the fact would have been noted long before—more particularly, as the two mountains formed part of the special study of Alexander von Humboldt during his residence in the Mexican capital.

